4.0 AFFECTED ENVIRONMENT

During project development, baseline field investigations of marine resources were conducted in New River Inlet, along the nearshore environment of Onslow Beach, along approximately 11.1 mi of the nearshore habitat and across 774 acres offshore of North Topsail Beach. The level and extent of field investigations were determined by the proposed construction activities described under all Alternatives, the associated cross-shore beach profile adjustment and the potential longshore spreading of fill. These investigations included the following:

- Bathymetric survey of New River Inlet (July 2004);
- Nearshore sidescan sonar survey from New River Inlet to USACE baseline station 730+00 (November 2004);
- Cultural resource survey (sidescan sonar and magnetom survey) of New River Inlet (2004 and 2007);
- Offshore geophysical survey (sidescan sonar, magnetom, seismic, bathymetric survey) (March to April 2005);
- Nearshore sidescan sonar and magnetom survey of Onslow Beach (April 2005);
- Beach profile survey (bathymetric and topographic survey) from USACE baseline station 1150+00 to 780+00 (July to August 2005);
- *In situ* investigations along the nearshore and offshore benthic habitats of Onslow Beach and North Topsail Beach to determine presence/absence of marine resources and biological characterization of verified hardbottom (June, August, October 2005 and August 2006);
- Nearshore sidescan sonar survey from USACE baseline station 740+00 to 560+00(August 2006); and
- Beach profile survey (bathymetric and topographic survey) from USACE baseline station 780+00 to 580+00 (September to October 2006).

The Permit Area is defined as the area anticipated to be impacted by primary and/or secondary, direct and/or indirect, project effects. The Permit Area was identified and delineated based on: 1) the location of verified hardbottom, 2) modeling results depicting potential sedimentation distribution in the inlet as a result of the realigned inlet channel (Alternatives 3, 5 and 6), 3) the point of intercept calculated along the oceanfront shoreline from proposed nourishment activities (Alternatives 3, 4, 5, and 6), and includes a 400-ft hardbottom buffer zone located offshore of USACE baseline stations 780+00 to 870+00 established by the Project Delivery Team (PDT).

The following section describes the natural resources identified within the Permit Area of the North Topsail Beach Shoreline Protection Project that may be affected by all project alternatives described in Section 3 – Project Alternatives.

4.1 GENERAL ENVIRONMENTAL SETTING OF THE PERMIT AREA

The Permit Area, an approximately 3,252-acre area, contains 11.1 mi of oceanfront shoreline along the Town of North Topsail Beach, approximately 2 mi of oceanfront shoreline of Onslow Beach, adjacent subtidal areas, and includes the New River Inlet (Figure 12). The Permit Area supports a wide diversity of estuarine and nearshore habitat types including those typically associated with a developed barrier island system in southeastern North Carolina. Habitat types include dry beach, dune, estuarine, high marsh, low marsh, intertidal shoal, marine intertidal, subtidal, upland hammock, and residential (Figures 12a – 12c). These habitats are defined in detail throughout the following sections. Table 9 lists the total acreage associated with each habitat found within the Permit Area.

Table 9
Permit Area Habitat Types and Acreage

Habitat Type[1]	Acres[2]
Dry Beach	125
Dune	111
Estuarine	38
High Marsh	8
Low Marsh	64
Intertidal Shoal	130
Marine Intertidal	488
Subtidal	1,879
Upland Hammock	55
Residential	354
Total	**3,252**

[1] Habitat types are based on remote sensing analysis using February 2005 aerial photography.
[2] Acreage totals were rounded to the nearest level of accuracy.

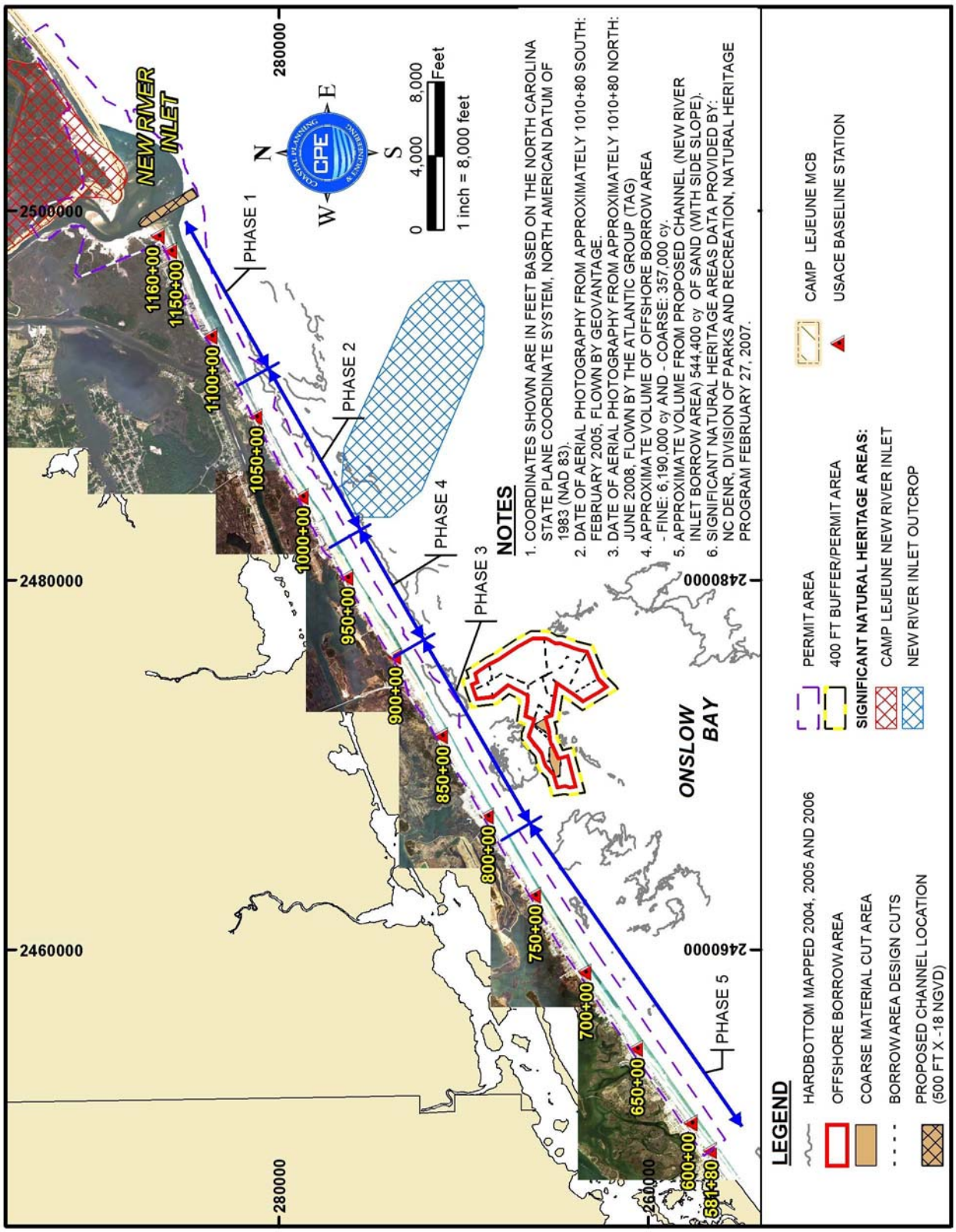
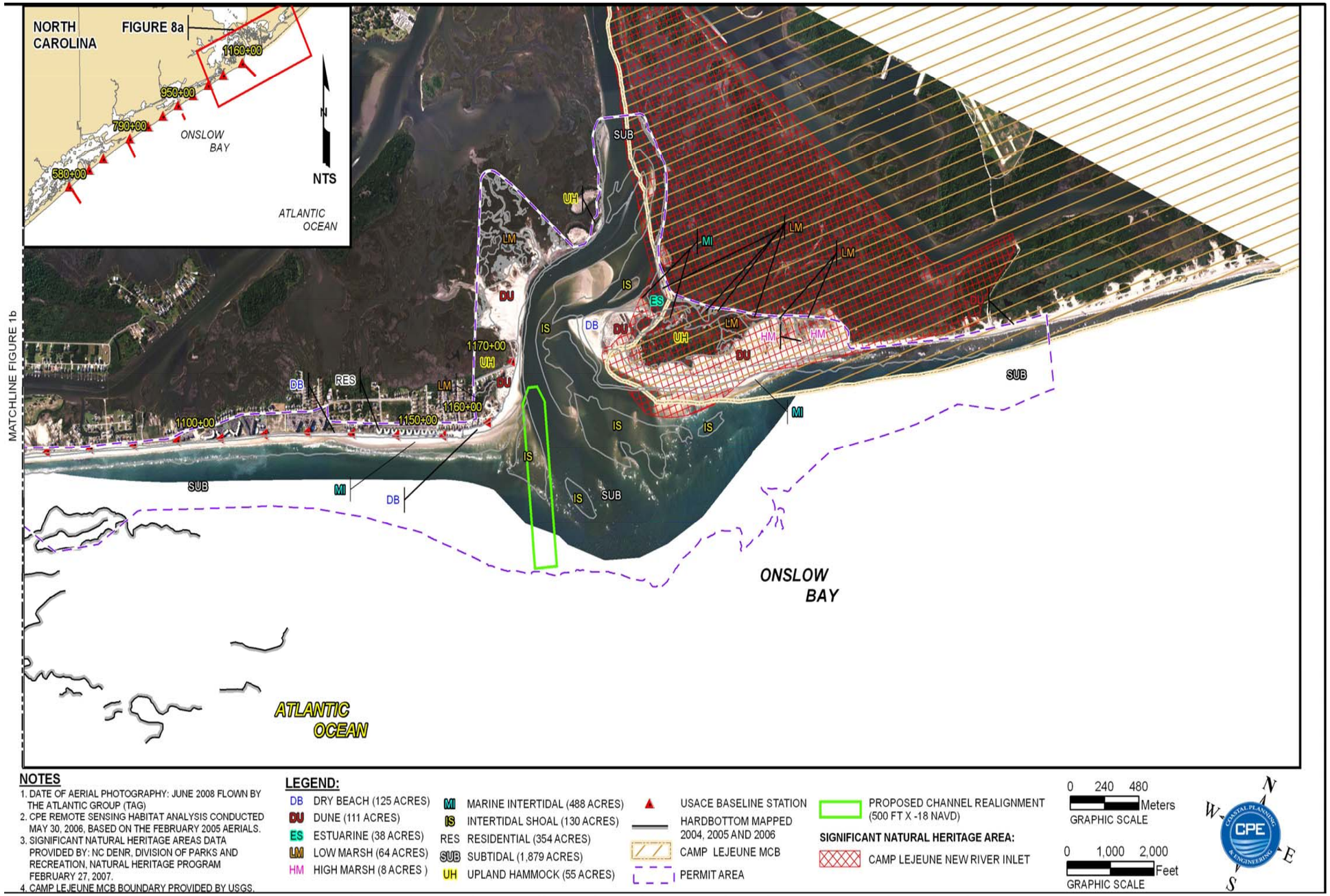


Figure 12. North Topsail Beach Environmental Setting Map



NOTES

1. DATE OF AERIAL PHOTOGRAPHY: JUNE 2008 FLOWN BY THE ATLANTIC GROUP (TAG)
2. CPE REMOTE SENSING HABITAT ANALYSIS CONDUCTED MAY 30, 2006, BASED ON THE FEBRUARY 2005 AERIALS.
3. SIGNIFICANT NATURAL HERITAGE AREAS DATA PROVIDED BY: NC DENR, DIVISION OF PARKS AND RECREATION, NATURAL HERITAGE PROGRAM FEBRUARY 27, 2007.
4. CAMP LEJEUNE MCB BOUNDARY PROVIDED BY USGS.

LEGEND:

- DB DRY BEACH (125 ACRES)
- DU DUNE (111 ACRES)
- ES ESTUARINE (38 ACRES)
- LM LOW MARSH (64 ACRES)
- HM HIGH MARSH (8 ACRES)
- MI MARINE INTERTIDAL (488 ACRES)
- IS INTERTIDAL SHOAL (130 ACRES)
- RES RESIDENTIAL (354 ACRES)
- SUB SUBTIDAL (1,879 ACRES)
- UH UPLAND HAMMOCK (55 ACRES)
- USACE BASELINE STATION
- HARDBOTTOM MAPPED 2004, 2005 AND 2006
- CAMP LEJEUNE MCB
- PERMIT AREA
- PROPOSED CHANNEL REALIGNMENT (500 FT X -18 NAVD)

SIGNIFICANT NATURAL HERITAGE AREA:

- CAMP LEJEUNE NEW RIVER INLET

0 240 480 Meters
GRAPHIC SCALE

0 1,000 2,000 Feet
GRAPHIC SCALE

Figure 12a. North Topsail Beach Environmental Setting Map – Northern Section

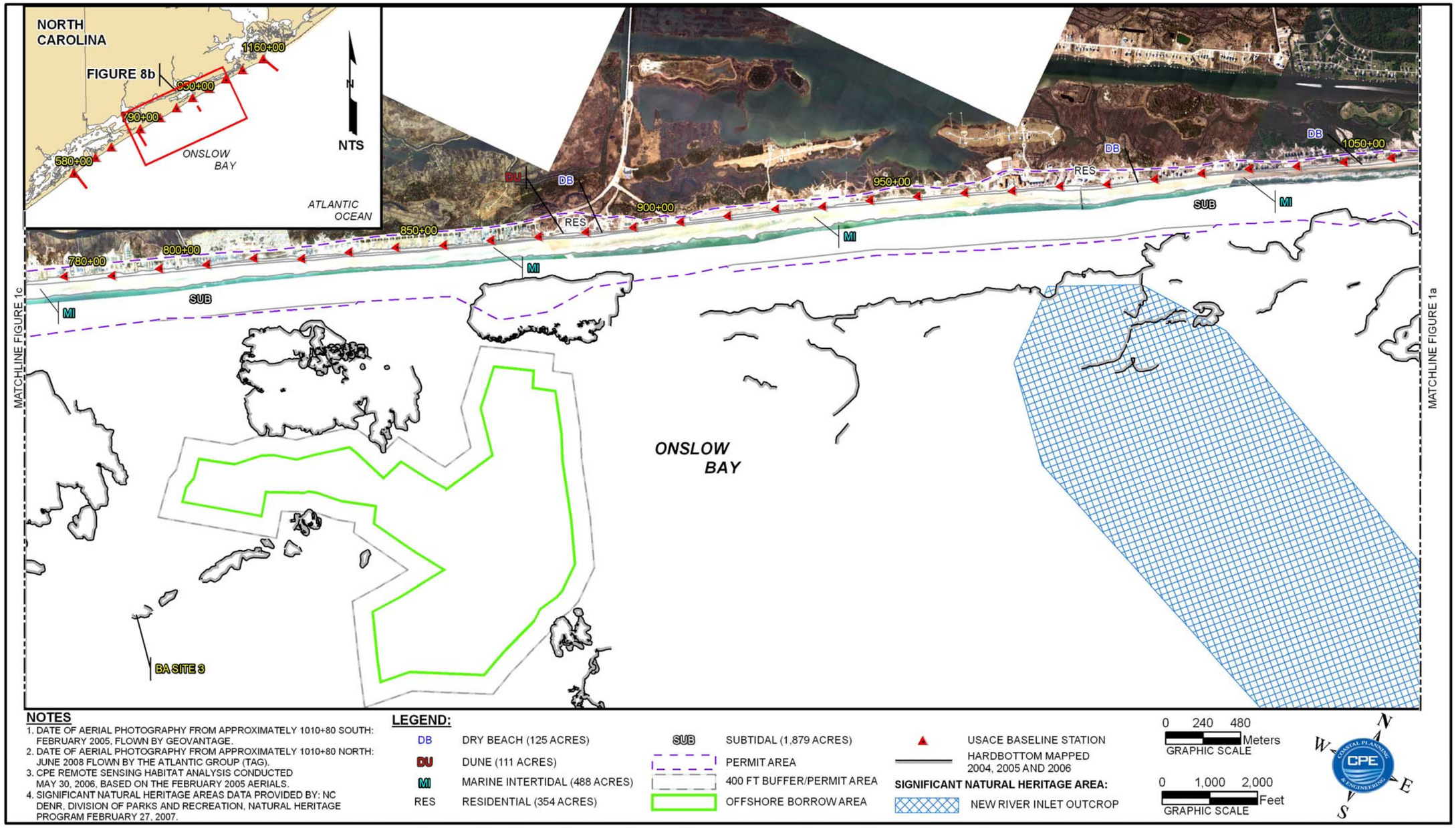


Figure 12b. North Topsail Beach Environmental Setting Map – Central Section

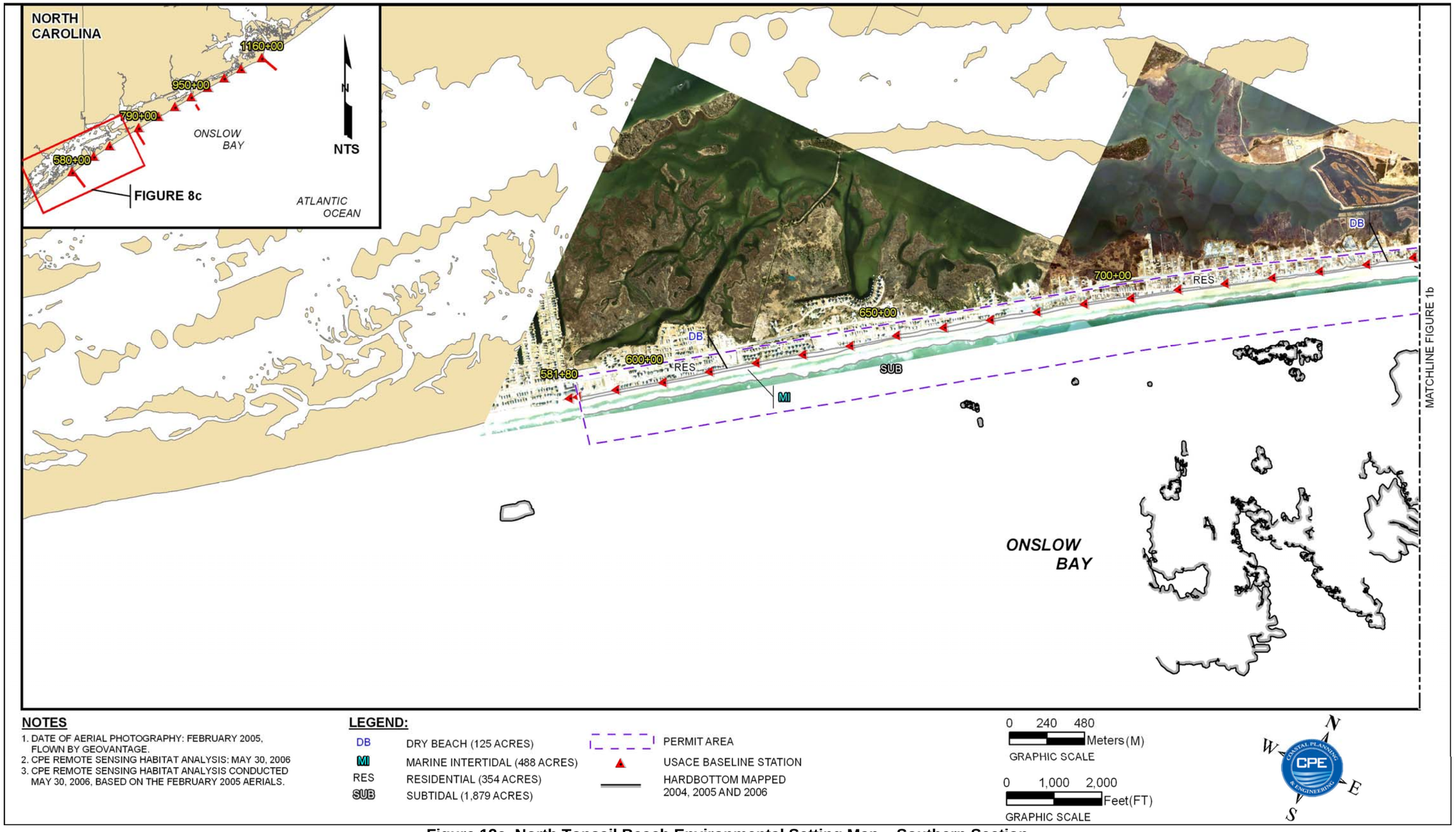


Figure 12c. North Topsail Beach Environmental Setting Map – Southern Section

Legal Town and County boundary limits found within the Permit Area are described as follows:

- Onslow County is located along the southeastern region of North Carolina, approximately 120 mi east of Raleigh and 50 mi north of Wilmington and includes the Towns of North Topsail Beach, Holly Ridge, Jacksonville, Richlands, Richmond, Swansboro and portions of Surf City. Onslow County is 756 square mi in size with an average elevation of 23 ft above sea level (Golden, 2000). The total population recorded for Onslow County in 2006 was 150,673 (USCB, 2006).

- The headwaters of New River originate in Onslow County and drain 470 square mi of land into the Mid-Atlantic Ocean. New River has three large bays: Morgan, Farnell and Stones, all of which are located in the upper reaches of the estuary (NMFS, 1999). As previously mentioned in Section 1.1, New River Inlet separates Topsail Island to the south and Onslow Beach to the north.

- Onslow Beach, an undeveloped barrier island 11 mi long, is located in the southeast portion of Onslow County, provides recreational access and military training grounds for Camp Lejeune Marine Corps Base. Camp Lejeune has been an active training facility specializing in combat readiness for the past 65 years. The training area includes 150,000 acres of land, including 11 acres of shoreline.

- Topsail Island consists of North Topsail Beach, Surf City and Topsail Beach and is located in both Onslow and Pender Counties. Topsail Island is 22 mi long (35.4 km) and is bordered by the Atlantic Ocean on the east side and an extensive marsh system and the Atlantic Intracoastal Waterway (AIWW) on the west side.

- The North Topsail Beach Town boundary, as described in the 1990 Town Ordinance Code of law, defines the boundaries as follows: “beginning at a point near the northern limit of Surf City and in the Intracoastal Waterway having N.C. Grid coordinates of North 260,907 East 2,445,050; thence along the Intracoastal Waterway North 47 degrees 04 minutes 23 seconds East 6015.6 ft; thence North 65 degrees 26 minutes 28 seconds East 44,583.2 ft; thence North 26 degrees 49 minutes 19 seconds East 7278.0 ft; thence North 08 degrees 08 minutes 23 seconds East 5021.5 ft; thence North 58 degrees 53 minutes 00 seconds East 7008.4 ft to a point in New River Inlet; thence leaving said Intracoastal Waterway and along New River Inlet South 00 degrees 00 minutes 00 seconds East 12,621.8 ft to a point in the Atlantic Ocean 1200 ft offshore; thence running parallel to the shoreline South 58 degrees 52 minutes 39 seconds West 59,111.2 ft to a

point in the Atlantic Ocean 700 ft offshore and lying near the northern limit of Surf City; thence along the Surf City line North 38 degrees 31 minutes 30 seconds West 6,978.8 ft to the point and place of beginning; containing 8,900 acres more or less and being all of Topsail Island which lies north of the current city limits of Surf City" (NTBTC, 1990).

New River Inlet Complex

The New River Inlet separates Topsail Island, a 22-mile developed barrier island to the southwest, and Onslow Beach, a 7.5-mile undeveloped barrier island to the northeast. Approximately 130 acres of intertidal shoal and approximately 1,879 acres of subtidal habitat, including adjacent shorelines, have been identified within the inlet complex. Other habitat types associated with the adjacent shoreline and estuarine environment are shown in Figure 12a. The inlet has undergone significant morphological changes over time. UNCW's Dr. William Cleary has investigated these changes and has identified four distinct phases in the evolution of the inlet since 1938. The first phase covered the period from 1938 to 1945 during which time the inlet was adjusting to the new hydrodynamic conditions associated with the construction of the AIWW and the channel connecting the AIWW with the City of Jacksonville. During this initial phase, the ebb tide delta began to enlarge and the inlet throat migrated to the southwest toward North Topsail Beach. The bar channel was also significantly skewed toward North Topsail Beach.

The second stage of inlet evolution covered the period from 1945 to approximately 1962. During this phase, the inlet assumed morphologic features recognized today including an enlarged ebb tide delta and extensive marginal flood channel on the northeast or Onslow Beach side of the inlet. The growth of the ebb tide delta stabilized by the mid-1950's, but continued to fluctuate in size around a mean area of 10.6 million square feet in response to varying climatic conditions, particularly the impact of tropical storms and nor'easters. During most of this period, the ocean bar channel was oriented either perpendicular to the adjacent shorelines or skewed slightly toward North Topsail Beach.

The third phase covers the period from 1962 to 1988 during which repetitive maintenance dredging of the ebb channel (channel dredging began in 1964) appeared to cause the apex of the delta to extend farther seaward. During this third phase of inlet evolution, the apex of the delta was offset to the southwest or off North Topsail Beach. These changes resulted in an asymmetric shape of the ebb tide delta in which most of the surface area of the delta was located on the northeast or Onslow Beach side of the bar channel.

The fourth and final phase of the inlet evolution covers the period from 1988 to the present during which time the bar channel has been oriented to the southeast or toward Onslow Beach.

Onslow Beach

Included in the Permit Area is the southern section of Onslow Beach, which consists of approximately two mi of oceanfront shoreline and backbarrier marsh. The habitat types specific to Onslow Beach and the Camp Lejeune Marine Corps Base include 71 acres of dune, 67 acres of marine intertidal habitat,18 acres of estuarine habitat, 41 acres of dry beach, 33 acres of upland hammock, 8 acres of high marsh and 13 acres of low marsh (Figure 12a).

North Topsail Beach

The Permit Area also includes approximately 11.1 mi of the North Topsail Beach oceanfront shoreline, associated residential communities and the backbarrier marsh system at the north end of Topsail Island. Habitat types identified along the north end of Topsail Island and specific to the oceanfront shoreline of North Topsail Beach include approximately 40 acres of dune, 421 acres of marine intertidal habitat, 20 acres of estuarine habitat, 84 acres of dry beach, 22 acres of upland hammock and 51 acres of low marsh. The residential community consists of approximately 354 acres (Figures 12b and 12c).

The oceanfront shorelines of North Topsail Beach and Onslow Beach are divided into three main ecosystems: dune, dry beach, and intertidal habitat. Sand dunes and the vegetation that comprise the dune system are important to the North Carolina coastline since they provide protection from storm surge, recreational areas for the public, and wildlife habitat. Based on an on-site inspection in spring 2007, approximately 10% of the North Topsail Beach oceanfront shoreline is vegetated (S. Mercer, pers. comm.). Changes in the vegetative community cover occurred in 2007 as a result of erosion from storm events in early spring 2007 and the addition of approximately 50,000 dune plants in summer 2007 by the Town of North Topsail Beach.

Extensive dune erosion prevention methods have been implemented by the Town of North Topsail Beach to maintain the dune systems along the oceanfront shoreline. Since 2000, the Town of North Topsail Beach and individual residents have been involved in dune restoration projects in which 610,000 plants have been installed at a cost of approximately $244,000. In addition to vegetation management to the frontal dune, nearly 75,000 linear ft of sand fence has been installed at a cost of approximately $225,000 (S. Mercer, pers. comm.).

The foredune system is characterized as the landward margin of the dry beach. Eroded material from the dune contributes to the dry beach located between the toe-of-dune and mean high water (MHW) line. Intertidal habitat is located between mean low water (MLW) and MHW and is strongly influenced by tidal and wave action.

4.1.1 GEOLOGY AND MORPHOLOGY OF THE STUDY AREA

New River Inlet is a dynamic system and one of a number of tidal inlets in North Carolina that, historically, have influenced the morphology and sedimentology of coastal barrier islands in North Carolina. Historic inlet activity is evidenced within the backbarrier system by a series of narrow marsh islands situated on the landward side of tidal creeks and small bays. Storm waves and flood currents propagating through paleo-tidal inlets built these elongated vegetated sand bodies (Cleary *et al*., 1976). Cleary and Hosier (1979) analyzed historic aerial photographs of the region which indicated that during the past few centuries, several generations of inlets had migrated along the same southwesterly pathway as New River Inlet.

The hydrography of the New River was modified in the 1930's with the dredging of the AIWW and the associated channel connecting the estuary and New River Inlet (Willson and Cleary, 2003). These changes in the hydraulic connection substantially increased the tidal prism resulting in an increased capacity of the outer bar by a factor of between 1938 and 1958. Side-cast dredging of the inlet throat and outer-bar channel, which began in the 1960's, may have also contributed to an increased tidal prism that in turn resulted in a six-fold increase in the size of the ebb-tidal delta (Cleary *et al*., 2000). A significant point to note is that the position and orientation of the ocean bar channel seem to control accretional/errosional trends, as reported by Cleary (1996).

Over the past 30 to 50 years, inlet modifications have played a role in the increased erosion of Onslow Beach (Cleary *et al*., 2001). The U.S. Army Corps of Engineers (USACE) (1989) estimated that the annual rate of erosion for the southern 4.3 mi of Onslow Beach was less than 1.1 ft/year between 1857 and 1933. The rate increased between 1938 and 1980 to 6.6 ft/year on average with localized rates of 26 ft/year (Benton *et al*., 1993). Modification of planforms for Onslow Beach and North Topsail Beach were associated with changes of the Inlet and the changing ebb-tidal delta shape (Willson and Cleary, 2003).

Riggs *et al*. (1996) has identified the New River Inlet coastal area as a submarine headland that forms a small seaward bulge in the coastline of central Onslow Bay. This shoreline protrusion was produced by the Oligocene Silverdale Formation, an indurated moldic limestone and calcareous cemented quartz sandstone unit. The Silverdale Formation crops out at or slightly below sea level near the mouth of the New River Inlet just beyond the ebb tidal shoal as a series of bathymetric ridges on the inner shelf on either side of New River Inlet (Crowson, 1980). Crowson mapped these prominent submarine rock features as a series of rock ridges that occur seaward of the lower shoreface. They have steep landward-facing scarps with smooth surfaces that dip gently away from the beach and have up to five ms of relief above the surrounding surface. The ridges

rise locally to about five ms below mean sea level, higher than the elevation of the lower shoreface. Crowson (1980) determined that this is probably high enough to cause major refraction of storm waves and currents and possibly affecting the patterns of erosion and deposition on adjacent beaches. Cleary and Hosier (1987) have confirmed that these rock ridges continue under Onslow Beach and into the back-barrier estuarine system.

4.1.2 Sand Source Location and Quality

The offshore borrow area is located approximately 0.4 to 1.6 mi offshore of the 2002 mean high water line between USACE baseline stations 780+00 and 870+00 (Figure 12a-c). As presented in Table 10, the offshore borrow area was divided into two sections, a section with finer grain size (composite mean grain size of 0.21 mm) containing approximately 6.19 million cy of material in 459 acres, and a coarser section (composite mean grain size of 0.33 mm) containing approximately 356,839 cy material within 23 acres. The ocean bar channel design with side slopes contains 635,800 cy of material within 45 acres. As previously mentioned in Section 3.2.3, only 544,400 cy of the material is beach compatible. The underlying 91,400 cy of clay and shell material will be placed in an upland disposal area. The mean grain size of the beach compatible material from the proposed ocean bar channel is 0.39 mm. Total volumes identified in these three zones (ocean bar channel, offshore finer, offshore coarser) equal approximately 7,096,000 cy of material.

In an effort to better manage the quality of the material placed on beaches, the North Carolina Coastal Resources Commission (CRC) adopted new State Sediment Criteria Rule Language (15A NCAC 07H .0312)(NCDCM, 2008a) (see Section 5.16.7.1). As previously stated in Section 3.2.3, all material to be used for this project strictly adheres to the state rules. Table 10 shows the values for the native beach, the state allowance, the associated state cutoff for compatible material and the values for the fill material.

Table 10
Characteristics of the Native Beach, Offshore Borrow Area and Channel Borrow Area Material

Source	% Silt	% Carbonate	% Granular	% Gravel	Volume (cy)	Acreage
Native Beach	1.5	26	1.07	0.43	NA	NA
State Standard Allowance	5	15	5	5	NA	NA
State Standard Cutoff	6.5	41	6.07	5.43	NA	NA
Offshore BA (Fine)	6.4	16	1.13	1.43	6,194,454	459
Offshore BA (Coarse)	1.75	20	0.63	0	356,839	23
Inlet Channel (with side slopes)	1.53	22	5.38	3.64	544,400	45
Total Volume of Borrow Areas					**7,187,093**	**527**

4.1.3 DEPLETED NATURAL RESOURCES

Immediately adjacent to the coastal inlets of North Carolina are lands that are vulnerable to natural processes, such as erosion and flooding. These inlet hazard zones, as designated by the North Carolina Coastal Area Management Act (CAMA), are important Areas of Environmental Concern (AEC). Many AECs have also been designated as Significant Natural Heritage Areas (SNHA) by the North Carolina Natural Heritage Program (NCNHP). The NCNHP has identified more than 2,000 SNHAs in North Carolina, which are defined as an area of land or water important for conservation of biodiversity. SNHA's contain one or more natural heritage elements such as high-quality or rare natural communities, rare species, and/or special animal habitats.

The NCNHP designated an SNHA offshore of New River Inlet (2489787.93E/272727.59N) identified as the New River Inlet Outcrop (Figure 12). This area is approximately 1,298 acres intermittently exposed rock outcrops of variable relief (CPE, 2006; Street *et al*., 2005; NCDHNR, 1981). New River Inlet Outcrop is approximately 2,000 ft (610 m) from shore at its closest point (USACE baseline station 970+00). Sidescan surveys were conducted by UNCW between 1999 and 2002 which encompasses a majority of the New River Inlet Outcrop

area. A detailed biological characterization study has not been conducted for this area although vibracores and seafloor mapping by diver surveys indicate the presence of a thin sedimentary cover on the shoreface (Johnston, 1998). Refer to the Final Project GIS for sidescan survey data collected along the nearshore and offshore of North Topsail Beach.

A second SNHA is located to the northeast of New River Inlet and encompasses a total of 928 acres (2502472.39E/ 292350.31N) (Camp Lejeune New River Inlet). This SNHA is primarily located within the Camp Lejeune Marine Corps Base with approximately 231 acres falling within the Permit Area. SNHA resources located within the Permit Area include a small dune grass community, seabeach amaranth (*Amaranthus pumilus*), and piping plovers (*Charadrius melodus*). Additional SNHAs exist within the Town of North Topsail Beach; however, they occur outside of the Permit Area and are not considered pertinent to the project.

4.2 THREATENED AND ENDANGERED SPECIES

The species considered under this assessment were obtained from updated lists of endangered and threatened (T&E) species for the project area (Onslow County, NC) from the NMFS (Southeast Regional Office, St. Petersburg, FL) (http://sero.nmfs.noaa.gov/pr/pdf/North%20Carolina.pdf) and the USFWS (Field Office, Raleigh, NC) (http://www.fws.gov/raleigh/es_tes.html) websites. These lists were combined to develop the following composite list of T&E species that could be present in the area based upon their geographic range. However, the actual occurrence of a species in the area would depend upon the availability of suitable habitat, the season of the year relative to a species' temperature tolerance and migratory habits, and other factors.

Table. 11 Federally listed threatened and endangered species identified or expected to occur in the vicinity of North Topsail Beach, Onslow County.

Common Name	Scientific Name	Status
North Atlantic Right whale	Eubaleana glacialis	Endangered
Sei whale	Balaenoptera borealis	Endangered
Sperm whale	Physeter macrocephalus	Endangered
Finback whale	Balaenoptera physalus	Endangered
Humpback whale	Megaptera novaeangliae	Endangered
Blue Whale	Balaenoptera musculus	Endangered
West Indian Manatee	Trichechus manatus	Endangered
Shortnose Sturgeon	Acipenser brevirostrum	Endangered
Loggerhead Sea Turtle	Caretta caretta	Threatened
Green Sea Turtle	Chelonia mydas	Threatened
Leatherback Sea Turtle	Dermochelys coriacea	Endangered
Hawksbill Turtle*	Eretmochelys imbricata	Endangered
Kemp's Ridley Sea Turtle*	Lepidochelys kempii	Endangered
Piping Plover	Charadrius melodus	Threatened
Roseate Tern*	Sterna dougallii	Endangered
Seabeach Amaranth	Amaranthus pumilus	Threatened

Source: USFWS (2006), http://nc-es.fws.gov/es/countyfr.html.

Key: Status Definition
Endangered - A taxon "in danger of extinction throughout all or a significant portion of its range."
Threatened - A taxon "likely to become endangered within the foreseeable future throughout all or a significant portion of its range."

* Indicates species not listed for Onslow County by USFWS (2006), but have been observed offshore (M. Godfrey, pers. comm.; S. S. Cameron, pers. comm.)

Any potential impacts on federally listed threatened and endangered species would be limited to those species that occur in habitats provided by the permit area. Federally listed species which could be present in the permit area during the proposed action are the humpback whale, northern Atlantic right whale, West Indian manatee, shortnose sturgeon, green sea turtle, hawksbill sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, loggerhead sea turtle, roseate tern, piping plover, and seabeach amaranth.

4.2.1 MAMMALS

The following section reviews and describes the threatened and endangered whales and manatees that may be found within the vicinity of North Topsail Beach.

Humpback and Right Whales

The whale species listed in Table 11 all occur infrequently in the ocean off the coast of North Carolina. Of these, only the North Atlantic Right Whale (Right Whale) and the humpback whale routinely come close enough inshore to encounter the project area.

Humpback whales were listed as "endangered" throughout their range on June 2, 1970 under the Endangered Species Act and are considered "depleted" under the Marine Mammal Protection Act. Humpbacks are often found in protected waters over shallow banks and shelf waters for breeding and feeding. They migrate toward the poles in summer and toward the tropics in winter and are in the vicinity of the North Carolina coast during seasonal migrations, especially between December and April. Since 1991, humpback whales have been seen in nearshore waters (within two (2) miles) of North Carolina with peak abundance in January through March. In the Western North Atlantic, humpback feeding grounds encompass the eastern coast of the United States, the Gulf of St. Lawrence, Newfoundland/Labrador, and western Greenland. Major prey species include small schooling fishes (herring, sand lance, capelin, mackerel, small Pollock, and haddock) and large zooplankton, mainly krill (up to 1.5 tons per day) (http://www.nmfs.noaa.gov). Based on an increased number of sightings and stranding data, the Chesapeake and Delaware Bays and the U.S. mid-Atlantic and southeastern states, particularly along Virginia and North Carolina coasts, have become increasingly important habitat for juvenile humpback whales (Wiley et al., 1995).

Humpback whales (*Megaptera novaeangliae*) are found in protected waters over shallow bars and shelf waters, which are used for breeding and feeding. They migrate toward the poles in the summer and toward the tropics in the winter to breeding and birthing grounds. Humpbacks visit the North Carolina coast during the migratory season, especially between the months of December and April (Conant, 1993). Migrating humpbacks can be found nearshore (North Carolina Aquariums, 1997), but probably migrate well offshore of the Permit Area to their primary wintering range (NMFS, 1991a).

The northern right whale (*Baleana glacialis*) is considered the world's most endangered large whale, with a total population of only around 300 individuals, and recent models predict this population will be extinct in less than 200 years (NMFS, 2006). Right whales may be found in ocean waters near the New River

Inlet during the winter months as they have calving grounds in waters along the coast of Georgia. The southeastern United States (Charleston, SC to the east coast of Florida) is considered critical habitat for the right whale because of these calving grounds (NMFS, 1991b). During late winter and early spring, right whales begin moving north past the North Carolina coast (this includes cow/calf pairs and others wintering south of Cape Hatteras). Migrations south to wintering areas occur as well and may include areas south of Cape Hatteras and begin as early as October (NMFS, 1991b).

West Indian Manatee

The West Indian manatee (*Trichechus manatus*) is listed as a federally protected species under the Endangered Species Act of 1973 and the Marine Mammal Protection Act of 1972. This mammal can be found in shallow waters (5 to 20 ft [1.5 to 6.1 ms]) of varying salinity levels including coastal bays, lagoons, estuaries and inland river systems. Manatees primarily feed on submerged aquatic vegetation, but can be found feeding on fish, consuming four to nine percent of their body weight in a single day (Schwartz, 1995; USFWS, 2006f). Sheltered areas such as bays, sounds, coves and canals are important for resting, feeding and reproductive activities (Humphrey, 1992).

The West Indian manatee can be found occupying the coastal, estuarine and some riverine habitats along the western Atlantic Ocean from North Carolina to the Florida Keys, Gulf of Mexico, the Caribbean Islands, Mexico, Central America and northern South America. During the winter months, the entire U.S. population typically moves to the waters surrounding Florida (Humphrey, 1992). However, manatees have been recorded in North Carolina and are most likely to occur from June through October when water temperatures are warmest (temperatures above 23.9ºC [75ºF]) (Schwartz, 1995; USFWS, 2006a). Manatees may overwinter (October through April) in North Carolina where the discharge from power plants provides warm water temperatures.

The greatest threat and causes of mortality for manatees are from boat collisions, as well as from other impacts including entanglement in fishing lines, entrapment and entanglement in locks, dams and culverts, and poaching. Long-term and cumulative impacts are associated with a loss of aquatic vegetated habitat and blocking of estuarine and riverine systems (Humphrey, 1992).

Though they are very difficult to census, the U.S. population for the West Indian Manatee is estimated at somewhere between 2000 and 4000. The NC Division of Parks and Recreation (2006) has reported manatee sightings in the last 20 years in the Counties of Beaufort, Brunswick, Carteret, Craven, Currituck, Dare, Hyde, New Hanover, Pamlico, Pender, and Pitt. Specific sightings include the following locations: Atlantic Intracoastal Waterway north of State Highway 101, July 2000; Beaufort waterfront and near Calico Creek, August 1999; Hammocks

Beach State Park, June 1998; Sportsman Pier in Atlantic Beach, August 1994; US Coast Guard Station at Fort Macon, August 1994; Barden Inlet, November 1992; Peletier Creek, October 1990; and the west end of Shackleford Banks, August 1983 (USFWS, 2006a). A dead manatee was observed within the New River in January 2004.

SHORTNOSE STURGEON

Populations of shortnose sturgeon range along the Atlantic seaboard from the Saint John River in New Brunswick, Canada to the Saint Johns River, Florida. It is apparent from historical accounts that this species may have once been fairly abundant throughout North Carolina's waters; however, many of these early records are unreliable due to confusion between this species and the Atlantic sturgeon (*Acipenser oxyrhynchus*). There are historical records of the shortnose sturgeon both in Albemarle Sound and the nearshore ocean (Dadswell, et al., 1984). During the winter of 1986-87, the shortnose sturgeon was taken from the Brunswick River, a component of the Cape Fear River basin, however, there are still no recent records of the species within the New River inlet vicinity of the project area (F. Rhode, pers. comm.). Because of the lack of suitable freshwater spawning areas in the project area and the requirement of low salinity waters by juveniles, any shortnose sturgeons present would most likely be non-spawning adults. The USACE and NMFS (2008 and 1997, respectively) provide additional detailed life history information associated with the life cycle requirements for the endangered shortnose sturgeon within Section 7 consultation documents.

Pollution, blockage of traditional spawning grounds, and over fishing are generally considered to be the principal causes of the decline of this species. The prohibition by NCDMF on taking any sturgeon in North Carolina should help to protect the species from commercial and recreational fishing pressure.

The shortnose sturgeon is principally a riverine species and is known to use three distinct portions of river systems: (1) non-tidal freshwater areas for spawning and occasional over wintering; (2) tidal areas in the vicinity of the fresh/saltwater mixing zone, year-round as juveniles and during the summer months as adults; and (3) high salinity estuarine areas (15 parts per thousand (ppt.) salinity or greater) as adults during the winter.

The shortnose sturgeon is a bottom feeder, consuming various invertebrates and stems and leaves of macrophytes. Adult foraging activities normally occur at night in shallow water areas adjacent to the deep-water areas occupied during the day. Juveniles are not known to leave deep-water areas and are expected to feed there.

4.2.2 SEA TURTLES AND TERRAPINS

Sea turtles are large marine reptiles that spend most of their lives in marine or estuarine habitats. Sea turtles can be found in subtropical and temperate oceans as well as in sub-artic seas around the world (Musick and Limpus, 1997). Several studies have shown that the beaches and inshore and offshore waters along the Atlantic Coast of the United States are important foraging and developmental habitats for many of the threatened and endangered species of sea turtles (Shoop and Kenney, 1992; Ehrhart, 1983; Keinath *et al*., 1987).

Five species of sea turtles utilize the waters of North Carolina for important breeding, feeding, and developmental areas, including: the loggerhead sea turtle (*Caretta caretta*); green sea turtle (*Chelonia mydas*); hawksbill sea turtle (*Eretmochelys imbricata*); Kemp's Ridley sea turtle (*Lepidochelys kempii*); and the leatherback sea turtle (*Dermochelys coriacea*) (Epperly *et al*., 1990; USFWS, 2003a; USFWS, 2003b; USFWS, 2003c; USFWS, 2003d; USFWS, 2003e;). Sea turtles can be found in offshore as well as inshore waters at all times of the year, although they are more common inshore during the spring, summer and fall months (Epperly *et al*., 1995).

Immigration of sea turtles into North Carolina's sounds and estuaries occurs most frequently in the spring with dispersal throughout the sounds as the waters warm. Emigration out of inshore waters occurs during the later part of fall when the waters began to cool. Although the exact numbers and frequencies of species inhabiting the inshore and offshore waters of North Carolina are not available, it is known that these habitats are used at various times throughout the year by all five sea turtle species discussed (Epperly *et al*., 1990).

Although sea turtles spend most of their lives in the ocean, female turtles must return to land to nest (Miller, 1997). Therefore, oceanfront beaches, such as those found along North Topsail Beach, provide an important habitat for sea turtle survival. Female sea turtles show nest site fidelity by returning to the nesting beach where they hatched (Limpus *et. al*., 1984; Limpus, 1985). Nesting females prefer beaches with limited lighting and open-water access, while other factors such as elevation from water inundation, dune vegetation, beach slope and the moisture and compaction of the sand may also influence site selection (Hendrickson, 1982; Mortimer, 1982).

North Carolina is near the northern limit for loggerhead sea turtle nesting along the east coast of the United States. According to Dr. Godfrey of the North Carolina Wildlife Resources Commission (NCWRC), green sea turtles and leatherbacks, in addition to loggerheads, reproduce on North Carolina beaches, although in much smaller numbers. More infrequently, Kemp's Ridley sea turtles nest along North Carolina's beaches (OBTF, 2006). For loggerhead sea turtles, the nesting season in North Carolina occurs between the months of May and

August, while green sea turtle nesting season occurs from June through September (USFWS, 2003f).

Since 1996, the Karen Beasley Sea Turtle Rescue and Rehabilitation Center has coordinated with the NCWRC regarding nest monitoring efforts along Topsail Island. Monitoring efforts are conducted by the Topsail Island Volunteer Organization, whose activities and data results are coordinated with the NCWRC Sea Turtle Project. Monitoring efforts include surveying the entire length of Topsail Island each morning during nesting season (May through August) and identifying and documenting sea turtle tracks and nests (KBSTRRC, 2006). The Town of North Topsail Beach works in conjunction with its neighboring towns of Topsail Beach and Surf City to educate its residents on sea turtle characteristics (http://ntbnc.org/env.aspx).

The U.S. Marine Corps (USMC) at Camp Lejeune oversees and conducts their own sea turtle monitoring efforts in accordance with the Integrated Natural Resource Management Plan. The USMC at Camp Lejeune has monitored sea turtle nesting on approximately 11 mi of Onslow Beach since 1979. Camp Lejeune personnel perform morning and night surveys from mid-May through August annually, documenting the location and number of sea turtle crawls, recording individual tagging and size data, and post and rope around sea turtle nests. Any nests discovered in the designated military training portion of Onslow Beach, or nests laid below the mean high tide line, are eligible for nest relocation. Nests are checked for hatchling emergence or predation, and hatchling tracks are documented to estimate hatchling success (USMC, 2006).

Loggerhead Sea Turtles

The loggerhead sea turtle (*Caretta caretta*) has been listed in the Federal Register as threatened throughout its range since July 28, 1978 (NMFS and USFWS, 1991). Adult loggerheads nest at night along sandy beaches and may nest from one to seven times within a nesting season (NMFS and USFWS, 1991). Loggerhead sea turtles are the only marine sea turtles that have been reported as predominantly nesting outside of the tropics (Bolten and Witherington, 2003).

Hatchling loggerheads migrate offshore into circular oceanic current systems (gyres) and are often found in drifting masses of *Sargassum* macroalgae until they have grown to be much larger juveniles (Carr, 1967; Fletmeyer, 1978). Loggerhead sea turtles will remain within the gyre for several years before leaving their pelagic habitats to return to their coastal foraging and nesting habitats (Klinger and Musick, 1995; Bolten *et al*., 1993).

Prior to 1989, a decline in the loggerhead population was directly correlated to the shrimp and fishery trawling industry. However, management measures to

reduce mortality rates, such as the Turtle Exclusion Device (TED), were not implemented until D. Crouse and L. Crowder proved through sensitivity analyses that the annual mortality of the large juveniles from fish trawling was substantially impacting its stock status (Lutz and Musick, 1997). TEDs were first used locally along the Gulf of Mexico, before being federally mandated for use in 1987. Even though these devices have proven to reduce mortality rates, population recovery remains mixed (Bolten and Witherington, 2003). Dr. Godfrey of the NCWRC expressed the difficulties in reporting sea turtle population and nesting trends since the availability of observers and consistencies in data collection can contribute to the reliability of the data (pers. comm.).

As indicated previously, the oceanfront shoreline of North Topsail Beach provides nesting habitat for loggerhead sea turtles. Table 12 lists the number of nests documented by the Topsail Island Volunteer Organization, under coordination by the NCWRC Sea Turtle Project, along North Topsail Beach for the years 2001 to 2006 (Godfrey, pers. comm.). Records of turtle nest locations observed along North Topsail Beach for the years 2001 to 2008 are depicted in Figures 13a through 13f as well as in Appendix G. Although volunteers have been collecting nesting data since 1996, GPS coordinates were collected for each nest beginning in 2001. A few of the nests plotted from GPS coordinates provided by the NCWRC plotted either seaward of MLW or landward of the dune crest, most likely due to variability in the GPS unit.

Table 12
Number of Sea Turtle Nests Documented on North Topsail Beach, 2001 to 2008
(Godfrey, pers. comm.)

Year	Loggerhead (*Caretta caretta*)	Green (*Chelonia mydas*)
2001	36	0
2002	88	0
2003	28	0
2004	52	0
2005	39	1
2006	37	0
2007	**33**	**0**
2008	**53**	**0**
Total	**366**	**1**

Sea turtle nesting experiences natural fluctuations, which account for the great variation in numbers of sea turtle nests each year as evident in Table 12. For instance, the entire southeastern coast of the United States reported extremely

low nest totals for 2003, which was also evident along the beaches of North Topsail Beach, compared to 2002 and 2004 (Godfrey, pers. comm.).

Sea turtles have also been reported nesting on Onslow Beach. The majority of nests are from loggerheads; however, green sea turtles have also been found to occasionally nest on Onslow Beach. According to observations conducted by Camp Lejeune military personnel, 191 sea turtle nests were observed on Onslow Beach between 2000 and 2004 (Appendix G) (Brewer, pers. comm.); 161 nests were reported between 2005 and August 2009 (C. Tenbrink, pers. comm.).

Green Sea Turtles

The green sea turtle (*Chelonia mydas*) breeding populations of Florida and the Pacific coast of Mexico are federally listed as endangered, while all other populations are listed as threatened under the Endangered Species Act of 1973. Green sea turtles can be found globally throughout warm tropical and temperate waters; however, their nesting and feeding grounds are predominantly in the tropic region. Green sea turtle nesting season will vary depending upon its locality.

In the North Atlantic, green sea turtles leave their pelagic habitats and enter coastal feeding grounds when they have reached a carapace length of 30 to 40 cm (11.8 to 15.8 inches) (Lutcavage and Musick, 1985). Feeding habitats for adults are specific to seagrasses and marine algae, while hatchlings may be found feeding on various plants and animals. Greens are generally found near seagrass habitats of shallow water environments, such as nearshore reefs, bays and inlets (NMFS and USFWS, 1991). Coral reefs and rocky patches may also be utilized for shelter and feeding when seagrass is not available (Hirth, 1997).

Along the U.S. beaches of the Atlantic, large nesting populations have been reported in Florida. Less significant nesting populations have been identified in the U.S. Virgin Islands, Puerto Rico, Georgia, South Carolina and North Carolina (USFWS, 2006a).

While loggerhead sea turtles are the most common species that nest within the Permit Area, a green sea turtle has been documented nesting on North Topsail Beach on one occasion (refer to Table 12). The plight of the green sea turtle is due to the increase in demand for subsistence living by some third-world cultures for commercial harvesting of eggs and meat (Pritchard, 1997). Other impacts are a result of the disease fibropapillomatosis that has plagued green sea turtle populations worldwide, most notably in Florida and Hawaii (USFWS, 2006b).

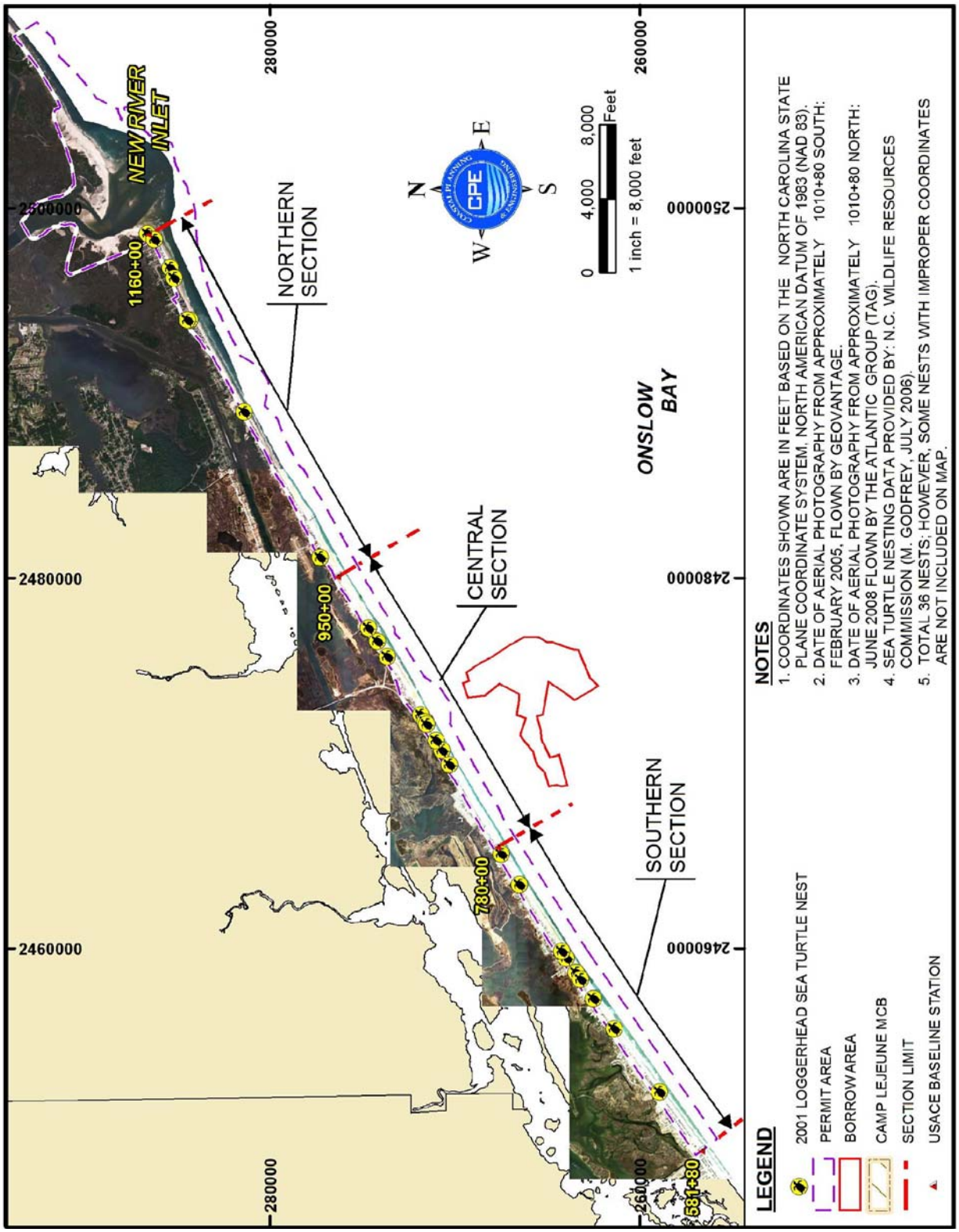


Figure 13a. 2001 Sea Turtle Nesting Locations

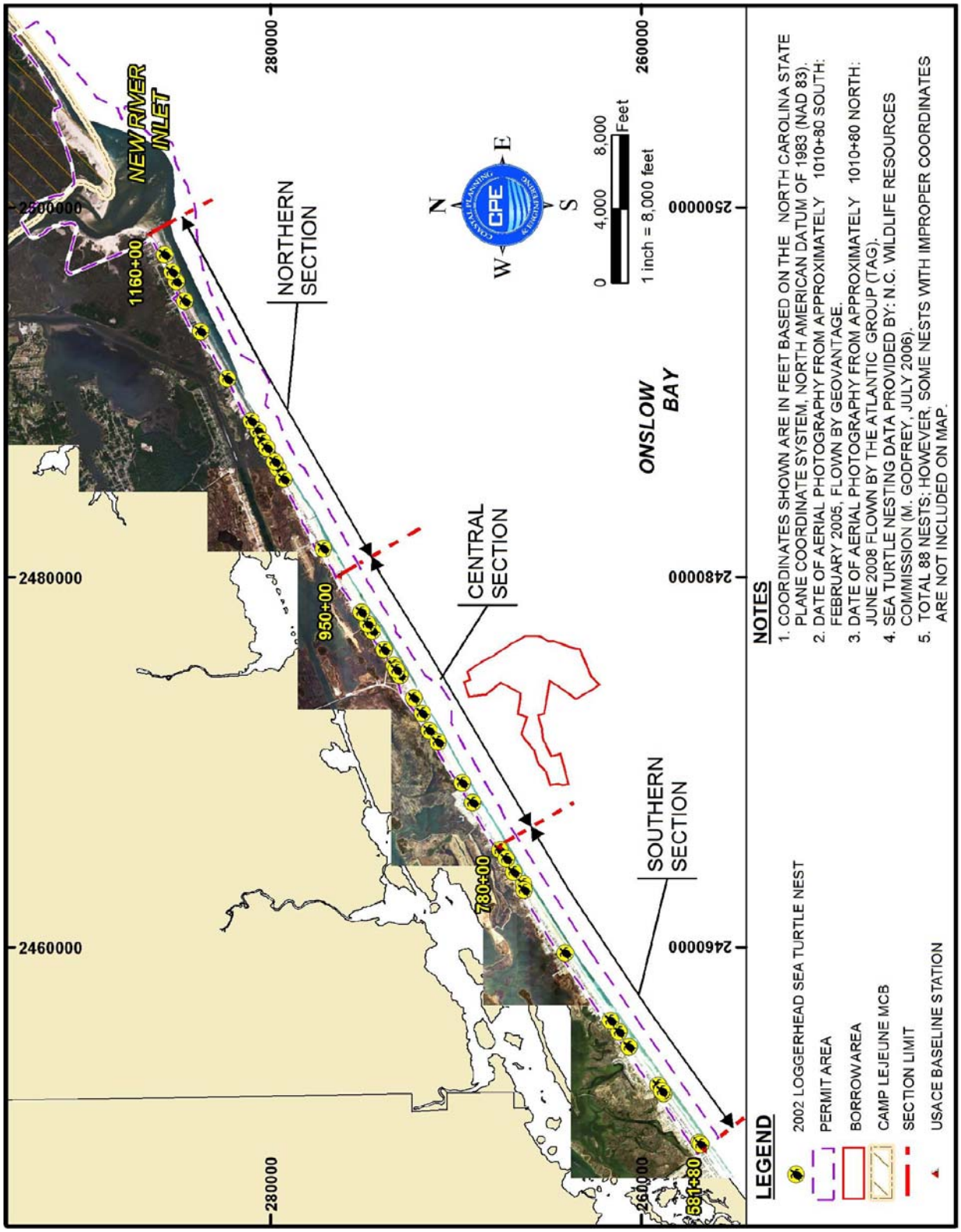


Figure 13b. 2002 Sea Turtle Nesting Locations

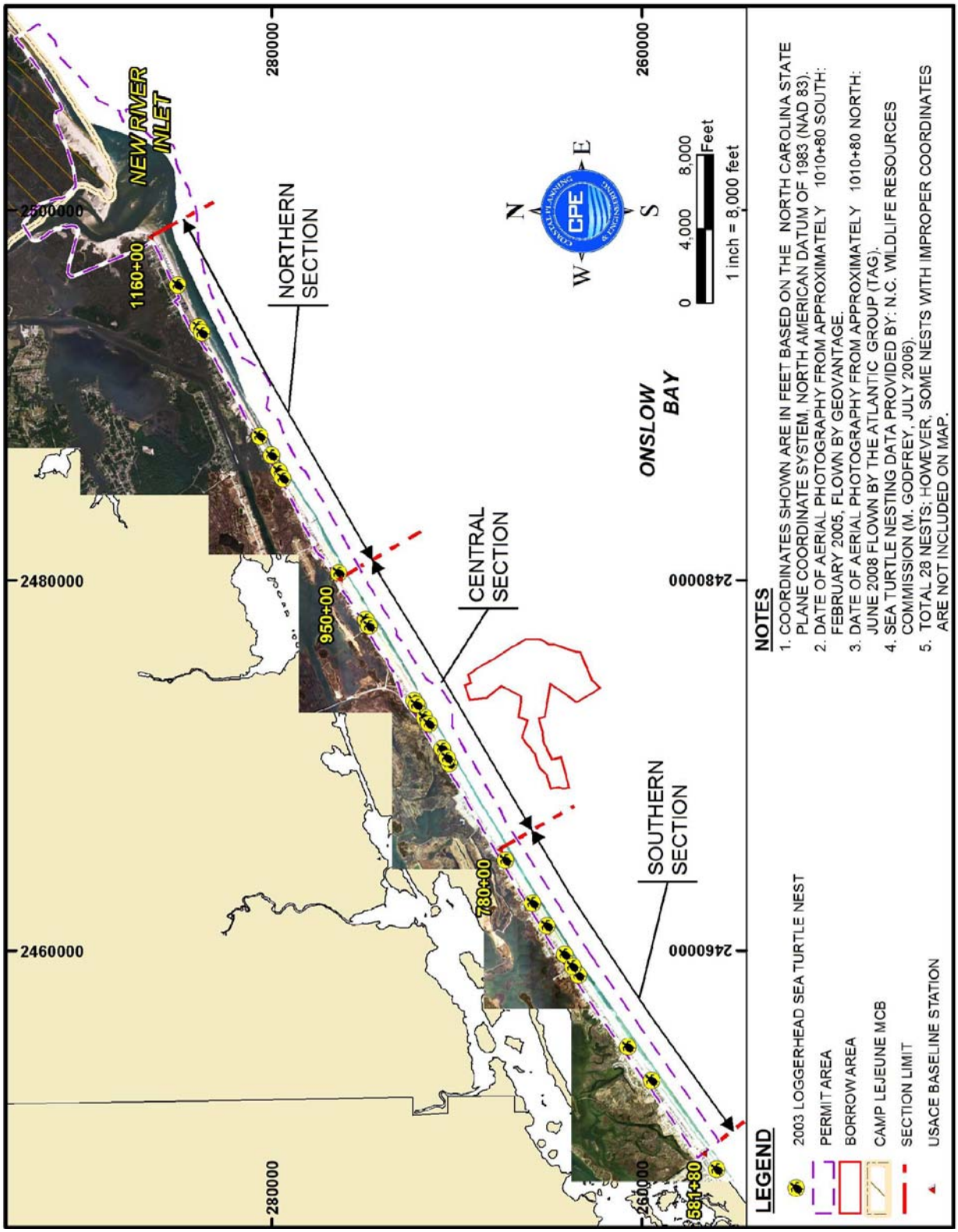


Figure 13c. 2003 Sea Turtle Nesting Locations

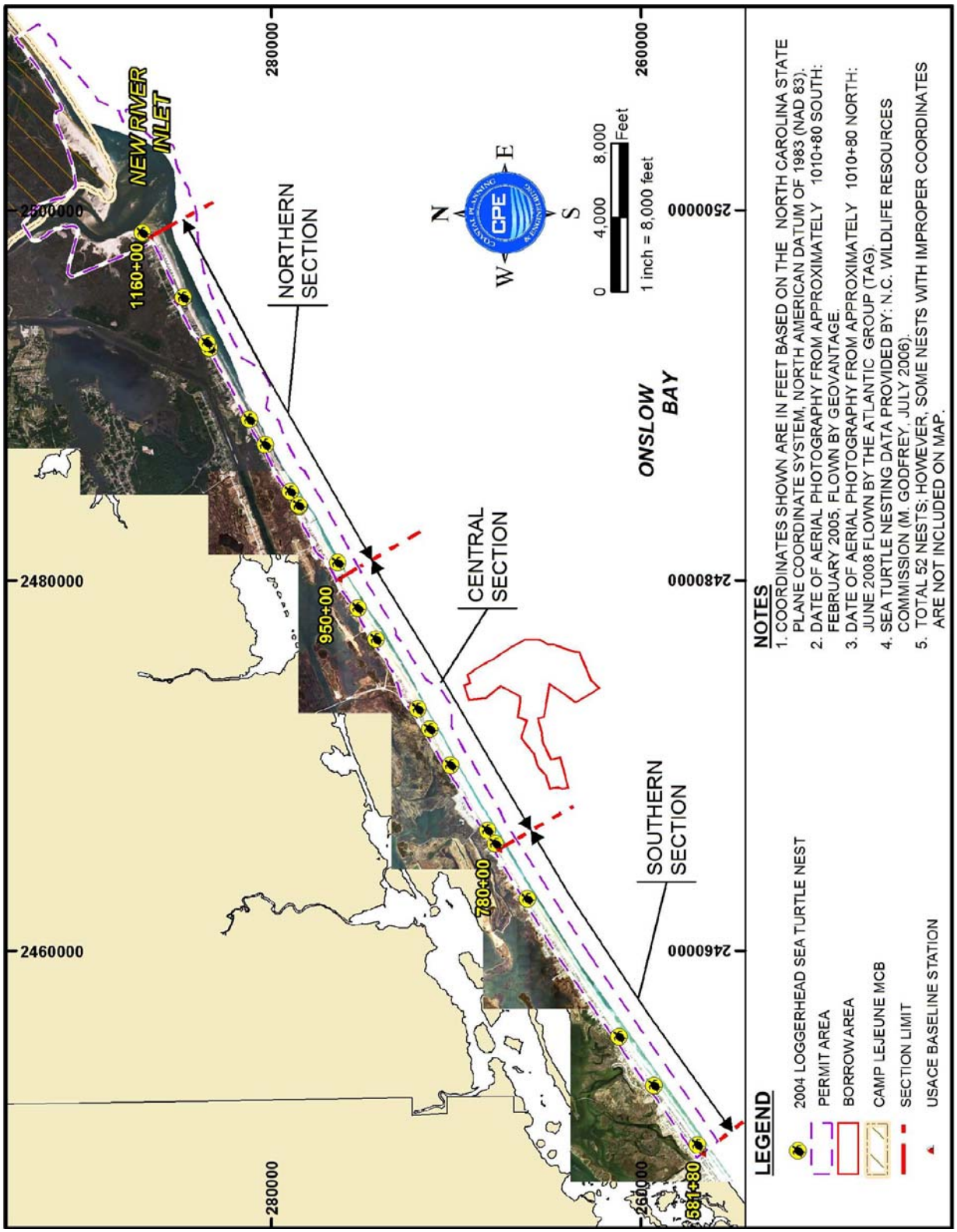


Figure 13d. 2004 Sea Turtle Nesting Locations

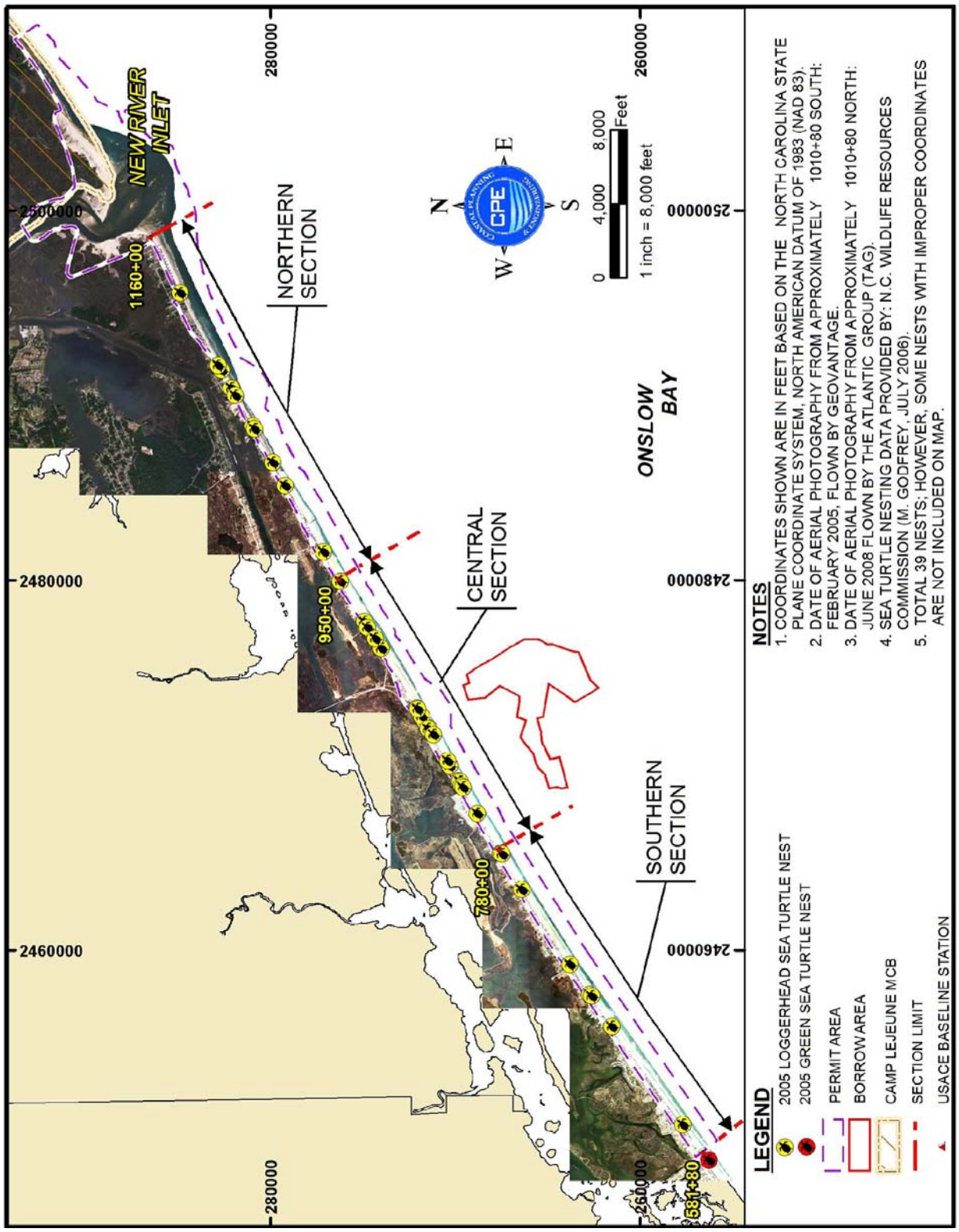


Figure 13e. 2005 Sea Turtle Nesting Locations

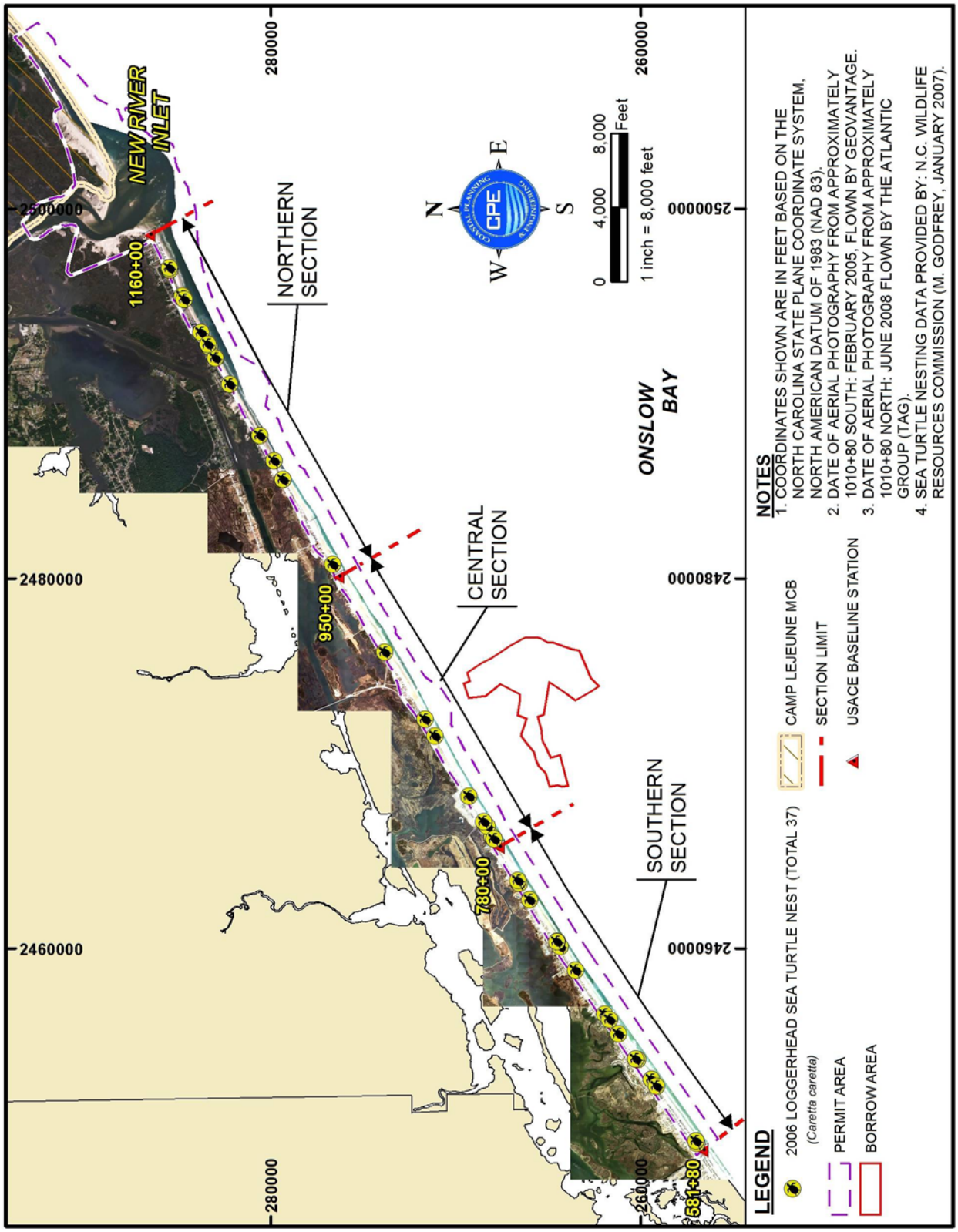


Figure 13f. 2006 Sea Turtle Nesting Locations

Hawksbill Sea Turtles

The Hawksbill (*Eretmochelys imbricata*) was listed as endangered under the Endangered Species Act in 1970. The hawksbill is also internationally protected under the Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora.

Hawksbill neonate behavior is similar to other sea turtles; they remain pelagic for several years before returning to coral reef habitats. Juveniles move from pelagic to coastal habitats at a much smaller size than other turtles (20 to 25 cm [to 10 inches] carapace length) (Lutcavage and Musick, 1985). Juveniles are not often seen in waters deeper than 19.8 ms (65 ft) (Witzell, 1983); however, they are frequently associated with floating *Sargassum* in the open ocean (Musick and Limpus, 1997).

Hawksbill turtles can be found in tropical and subtropical waters of the Atlantic, Pacific and Indian Oceans. These turtles are widely distributed in the Caribbean and western parts of the Atlantic Ocean. Within the U.S., hawksbill turtles are most common in the waters surrounding Puerto Rico, U.S. Virgin Islands and Florida (USDC, 1998). Hawksbills are recorded in the continental U.S. from all the Gulf states, and from the eastern seaboard as far north as Massachusetts, but sightings north of Florida are rare (NMFS and USFWS, 1993). These turtles prefer the clear shallow waters of coral reefs, creeks, estuaries and lagoons in tropical areas. They tend to feed on sponges, algae, fish, mollusks, and other benthic species found in the nearshore zone.

Exploitation of the hawksbill sea turtle for national and international trade of its shell has largely contributed to the demise of its population. The hawksbill has experienced an 80% decline in population over the past century mainly because of the tortoise shell trade. Continued shell trade, coastal development and beach armoring, beachfront lighting, predation, pollution and incidental take all contribute to the demise of the hawksbill (USFWS, 2006c).

Kemp's Ridley Sea Turtles

Kemp's Ridley (*Lepidochelys kempii*) is listed as endangered under the Endangered Species Act. These are the smallest of the eight species of turtles averaging 35 to 45 kilograms (78 to 100 lbs) (Marquez, 1994). As juveniles, Kemp's ridley turtles feed primarily on crabs, clams, mussels and shrimp and are most commonly found in productive coastal and estuarine areas.

Most sea turtle species are widely distributed; however, the Kemp's ridley is mostly restricted to the Gulf of Mexico (Miller, 1997). They have also been sighted in shallow coastal waters along the east coast of the United States and occasionally found stranded on the beaches of North Carolina (Mihnovets, 2003).

These strandings may be attributed to the juvenile sea turtles getting caught in the southern Gulf of Mexico loop current that eventually moves these turtles east and north up the eastern Atlantic coast (Musick and Limpus, 1997). The largest current threat to the Kemp's ridley sea turtle population is by drowning in shrimp nets (approximately 500 to 5,000 sea turtles per year) (Keuper-Bennett and Bennett, 2004).

Conservations measures, such as the "head-starting" program initiated in the late 1970's, are thought to contribute to the Kemp's ridley population recovery. However, the Kemp's ridley sea turtle still remains the rarest sea turtle in the world (Pritchard, 1997).

Leatherback Sea Turtles

The leatherback (*Dermochelys coriacea*) sea turtle is federally listed as endangered throughout its range in the United States under the Endangered Species Act of 1973. The leatherback is one of the largest sea turtles, with an average-sized adult weighing 450 kilograms (1000 lbs) (Pritchard, 1997). This sea turtle is barrel-shaped in appearance with a rigid carapace that is leather-like. The front flippers of this sea turtle are proportionally longer than any other sea turtle, with a flipper span extending to 270 cm (8.8 ft) for an adult (USFWS, 2006d).

Considered to be the most pelagic of sea turtle species, hatchlings migrate offshore and remain pelagic through their adult lives. Leatherbacks feed throughout the water column from depths of 50 ms (164 ft) recorded in Australia, to surface waters and nearshore shallow environments of 4 ms (13 ft). According to Bjorndal (1997), these turtles primarily prey upon jellyfish, squid, shrimp, and other types of fish.

Nesting populations of leatherback sea turtles were first discovered in the 1950's; however, most were not recorded until the 1960's to 1970's (Lutz and Musick, 1997). Major nesting grounds have been discovered in Mexico, although the range of the leatherback extends from Nova Scotia south to Puerto Rico and the U.S. Virgin Islands (Pritchard, 1997). A large nesting population occurs on the northern Caribbean coast of Panama whereas, small nesting populations also occur in Florida, St. Croix, and Puerto Rico. In the U.S., the nesting season begins in March and continues throughout July (USFWS, 2007a).

Although nesting in North Carolina is rare, approximately 12 leatherback turtle nests have been confirmed in the past seven years. Leatherback sea turtles nest an average of five to seven times within a nesting season, with an observed maximum of eleven nests. The average inter-nesting interval is about nine to ten days (USFWS, 2007). Therefore Rabon *et al*. (2003) hypothesized that these nesting activities could be attributed to a single female. While infrequently found

in inshore waters, Epperly *et al*. (1995) reported that, on average, 15 leatherback sea turtles were sighted per year in inshore waters (within three mi of shore) of North Carolina between 1989 and 1992. According to Epperly *et al*. (1995) these inshore sightings coincided with the appearance of jellyfish and leatherback sightings diminished by late June.

Carolina Diamondback Terrapin

The Carolina diamondback terrapin (*Malaclemys terrapin centrata*), is State and Federally listed as a Species of Special Concern. They are commonly found within the inshore waters of North Carolina. This subspecies ranges from Cape Hatteras to northeastern Florida and has a wide tolerance for saltwater (Robinson and Dunson, 1975). They are the only North American turtle species native to brackish waters and are commonly found in salt marshes, impoundments, tidal creeks, lagoons and mud flats. These areas serve as central feeding grounds for this species throughout most of the year. Carolina diamondbacks are primarily carnivorous, feeding upon crabs, snails and nereid worms.

During the winter months, Carolina diamondback terrapins hibernate in the muddy burrows along the embankments of tidal creeks. Nesting typically occurs after the mating season in May. Females build nests in sandy substrates above the high tide mark during the months of May and June and eggs are left to incubate for 60 to 120 days depending upon temperature conditions within the nest (Martof *et al*., 1980). Unlike other sea turtles, emergence takes place during the day and hatching diamondback terrapins move to the surrounding vegetation rather than out to sea. It has been reported that juvenile terrapins (2.5 to 7 mm [1 to 3 inches]) spend their time out of water living beneath surface debris and matted *Spartina*, rarely entering open water. Adult terrapins spend their summer months in full marine conditions and other times of the year are spent in submerged mud and brackish water (Davenport, 1992).

The marshes on the sound side of North Topsail Beach and Onslow Beach provide habitat for the Carolina diamondback terrapin (H. H. LeGrand, pers. comm.). According to observations reported to the NC Natural Heritage Program, seven Carolina diamondback terrapin sites were recorded in the marshes behind the western end of Onslow Beach on June 17, 1995 (Appendix G). Data on Carolina diamondback terrapins was received from the NC Natural Heritage Program, as well as the North Carolina Museum of Natural Sciences. However this data is considered to be outdated (pre 1996) and no observations were recorded within the Permit Area (LeGrand pers. comm.; Beane, pers. comm.).

4.2.3 BIRDS

The following section reviews and describes threatened and endangered birds species, both breeding and non-breeding, that have been found within the vicinity of the Permit Area. Bird species of special concern and of high conservation priority in North Carolina are also listed and discussed.

Roseate Tern

The roseate tern (*Sterna dougallii)* is listed as endangered under the Federal Endangered Species Act as of November 2, 1987 (USFWS, 1993a). It is globally ranked as G4 and considered as globally secure throughout its range (NCNHP, 2006). In 1998 the world population was estimated at approximately 40,000 pairs, and the northeastern population at around 3,500 pairs (USFWS, 2004).

This bird is primarily pelagic, returning to land only to nest and roost. The roseate tern is frequently confused with other medium-size birds; however, this bird has a thin, slender body, round head, thin bill and long, forked tail. The adult breeding season is from July through August/September. During the breeding season, three quarters of the legs and bill turn an orange-red color (Sibley, 2000; USFWS, 2006e).

This waterbird breeds primarily on small offshore islands or islets along the Atlantic Ocean (along the east coast from Canada to Brazil). Nesting generally occurs in colonies in association with other species such as the common tern (*Sterna hirundo*) near vegetation or jagged rock, on open sandy beaches, close to the waterline on narrow ledges of emerging rocks, or among coral rubble (USFWS, 2002a). This species has been found south of Cape Hatteras, particularly at Cape Point within the Cape Hatteras National Seashore, during the months of July and August and may pass through the coast of North Carolina from March to May and August to October en route to their breeding grounds (New York to Nova Scotia) or wintering grounds (South America), respectively (NCDPR, 2006). However, the roseate tern has not been reported in the vicinity of New River Inlet or Onslow County in over twenty years (USFWS, 2006). They migrate offshore and are rarely seen along North Carolina coasts (S. Cameron, pers. comm.).

Piping Plover

The piping plover (*Charadrius melodus*) is federally listed under the Federal Endangered Species Act of 1973, as amended with three separate breeding populations in North America: 1) the Atlantic Coast population (threatened), 2) the Northern Great Plains population (threatened), and 3) the Great Lakes population (endangered). Piping plovers are also listed as threatened throughout their wintering range (USFWS, 1996). The Atlantic Coast population breeds

along the east coast of North America, from the Canadian Maritime Provinces to North Carolina. The Northern Great Plains population can be found breeding from southern Alberta to Manitoba and south to Nebraska. The Great Lakes population breeds along the shorelines of the Great Lakes. All three populations migrate to the coastal shorelines of the South Atlantic, Gulf of Mexico and the beaches of the Caribbean Islands to winter (USFWS, 2006f).

The habitat for wintering piping plover is protected under a Critical Habitat listing as identified in the Federal Register (50 CFR Part 17). A Critical Habitat designation recognizes specific areas "that are essential to the conservation of a listed species, and that may require species management considerations or protection". Although areas along the coast of North Carolina are designated as Critical Habitat for Wintering Piping Plover (USDOI, 2001), there is no Critical Habitat for Wintering Piping Plover in the vicinity of the Permit Area (S. Everhart, pers. comm.).

The Atlantic Coast population of piping plovers nest in dry sand habitats above the high tide line along coastal beaches, spits, flats, barrier islands and other sparsely vegetated dune and beach environments, while interior populations breed along lake shores and river margins (USFWS, 2007b). Their nests are comprised of sand and shell material making them well camouflaged, with an average clutch size of three to four (USFWS, 1996). Plovers primarily feed on invertebrates endemic to the wet sand environment between mean low and mean high water (USFWS, 1996).

Until 1918, when the Migratory Bird Treaty Act was implemented, hunters were considered to be the primary cause for the population decline in all three geographic breeding regions during the 19th and early 20th centuries. From the 1940's until now, habitat loss, increased predation and disturbance from humans and pets has continued to be cited as major contributing factors for the decline of the Atlantic Coast population (USFWS, 1996).

The loss of Atlantic Coast habitat has largely been attributed to the development of permanent structures, which alters natural beach processes and prevents natural overwash events. Structures that have been identified as having significant effect on nesting habitat include seawalls, jetties, piers, homes, parking lots, and other interfering structures. Animal and human disturbances, depending upon duration and proximity of perceived threat, may result in adults leaving eggs or chicks exposed to predators or inclement weather and may result in disruption of nesting, foraging, and roosting behaviors.

Adult mortality has been identified as a key determinant in population trends. The physical location of nest sites or clutch size were not found to play a strong role in regulation of populations (Burger, 1987; 1991). Juvenile mortality may not have as strong of an effect on populations as adult mortality; however,

reproductive success is lower in areas with high human disturbance (Burger, 1987; 1991). While piping plovers illustrate acclimation to human disturbances via flexible habitat use (i.e. the ability to forage in a different habitat e.g. backbay or ocean) abandonment of native habitats often results (Burger, 1994).

The loss of bird migration habitats in the coastal zone has been extensive. Habitat and shoreline armoring, along with the disturbance from humans and pets have reduced intertidal habitats used by piping plovers and other shorebirds for foraging, roosting and nesting.

The North Carolina breeding population experienced a decline in the number of piping plover breeding pairs between 1989 to 2003, decreasing from 55 pairs to 24 pairs (USFWS, 2006f). However, preliminary estimates indicate a slight increase in breeding pairs to 37 in 2005, and to 46 pairs in 2006 (USFWS, 2007b and 2007c). While plover populations have increased in NC in recent years, problems with low productivity remain, leaving the population vulnerable to problems associated with very small, sparsely distributed populations (e.g., difficulties finding mates) (USFWS, 2004b).

Piping plovers have been documented arriving on their breeding grounds in North Carolina beginning as early as mid-March and by mid-July adults and young may begin to depart for their wintering areas. The piping plover is present year round in North Carolina and utilizes the coastal habitats for foraging, roosting, and nesting (S. Cameron, pers. comm.).

Non-breeding piping plovers have been observed utilizing the New River Inlet area during migration and over winter, although they have not been observed breeding there for about twelve years (S. Cameron, pers. comm.). This finding does not indicate that piping plovers do not utilize New River Inlet habitats for breeding but may be due to lack of survey resources. Based on survey data conducted since 1989 (annual nesting habitat surveys, coast-wide wintering surveys, limited opportunistic surveys, and pre-construction monitoring) a total of 48 piping plovers have been identified within the project vicinity (Table 13). The use of the North Topsail Beach-New River Inlet complex by the piping plover is unknown as very few non-breeding bird surveys have been conducted (S. Cameron, pers. comm.). Surveys conducted on Onslow Beach by US Marine Corps personnel observed 171 piping plovers between 1996 and 2009 (Table 14) (S. Cameron, pers. comm.; C. Tenbrink, pers. comm.). However these surveys include Camp Lejeune surveys as well as incidental observations and were not as limited as those conducted on North Topsail Beach (S. Everhart, pers. comm.). It should also be noted that non-breeding piping plover data provided by NCWRC is based on just a few opportunistic sightings and not regular surveys. Furthermore, data from different days is not necessarily additive (e.g. may be seeing the same birds on different days). Breeding surveys are more complete and are conducted annually while wintering surveys are conducted every five

years. No nests have been documented on Onslow Beach between 1996 and 2008 (S. Brewer, pers. comm.; S. Cameron, pers. comm.); however, a single piping plover nest was observed on Onslow Beach in 2009 in which the nest hatched on July 5, 2009 (K. Ray, pers. comm.). A map illustrating piping plover sightings recorded by Camp Lejeune biologists between 2000 and 2004 is included in Appendix G (S. Cameron, pers. comm).

Table 13
Piping Plover Survey Data (1992 to 2009) for New River Inlet Complex (includes North Topsail Beach, New River Inlet, and southern section of Onslow Beach) (S. Cameron, pers. comm.)

Location	Survey Date	Season	# of Birds	# of Breeding Pairs
North Topsail Beach - New River Inlet	7/1/1992	Breeding	2	1
North Topsail Beach	7/1/1993	Breeding	2	1
North Topsail Beach - New River Inlet	4/30/2000	Spring Migration	2	NA
North Topsail Beach	10/18/2000	Fall Migration	1	NA
North Topsail Beach - New River Inlet	9/8/2001	Fall Migration	1	NA
North Topsail Beach	9/2/2004	Fall Migration	2	NA
New River Inlet	8/15/2008	Fall Migration	1	NA
Onslow Beach	8/15/2008	Fall Migration	2	NA
North Topsail Beach – New River Inlet	8/24/2008	Fall Migration	1	NA
Onslow Beach	8/24/2008	Fall Migration	4	NA
North Topsail Beach - New River Inlet	8/26/2008	Fall Migration	1	NA
Onslow Beach	9/03/2008	Fall Migration	3	NA
Onslow Beach	09/23/2008	Fall Migration	1	NA
Onslow Beach	10/15/2008	Fall Migration	1	NA

Location	Survey Date	Season	# of Birds	# of Breeding Pairs
North Topsail Beach – New River Inlet	3/30/2009	Spring Migration	1	NA
Onslow Beach	3/30/2009	Spring Migration	10	NA
Onslow Beach	4/05/2009	Spring Migration	18	NA
Onslow Beach	4/17/2009	Spring Migration	6	NA
Onslow Beach	4/27/2009	Spring Migration	1	NA
North Topsail Beach – New River Inlet	5/15/2009	Spring Migration	6	NA
Onslow Beach	7/2009	Breeding	2	1

Table 14
Piping Plover Survey Data (1996 to 2006) for Onslow Beach
(S. Cameron, pers. comm.)

Year	Season	Number of Birds
1996	Winter	1
1997-1999	NA	NA
2000	Spring Migration	11
2000	Breeding	2
2000	Fall Migration	9
2001	Breeding	2
2001	Fall Migration	7
2001	Spring Migration	4
2001	Winter	7
2002	Fall Migration	7
2002	Spring Migration	11
2002	Winter	3
2003	Breeding	3
2003	Fall Migration	4
2003	Spring Migration	9
2003	Winter	4
2004	Spring Migration	1
2004	Breeding	4
2004	Fall Migration	1
2005	Breeding	6
2005	Fall Migration	3
2006	Spring Migration	14
2006	Breeding	1
2006	Fall Migration	15
2009	NA	42
	Total	**171**

NA – Historic data for the period of 1997 to 1999 is currently unavailable.
NA - The data provided by USMC for 2009 was not separated into seasons.

Wilson's Plover

The Wilson's plover (*Charadrius wilsonia*) is designated by the State of North Carolina as Significantly Rare. This is a peripheral species (North Carolina lies at the periphery of its species range) requiring monitoring by the NCNHP. There is no federal status for this species, and it is considered globally secure (G5 rank) (NCNHP, 2006). Wilson's plovers are, however, listed nationally as species of

high conservation concern (S. Everhart, pers. comm.). Wilson's plover breeds in eastern and southern coastal areas of the United States and overwinters along the Florida Atlantic coast and Gulf coasts to northern South America. Wilson's plovers are considered by the NCWRC to be regular breeders in the Permit Area (Everhart pers. comm.). From 1989 to 2004 as well as from 2008 to 2009, surveys were conducted in or near the Permit Area (New River Inlet, southern two miles of Onslow Beach and North Topsail Beach) (Table 15). Surveys conducted by the NCWRC in 2005 and 2006 confirmed Wilson's plover nesting on the north end of North Topsail Beach. It should also be noted that non-breeding Wilson's plover data provided by NCWRC is based on just a few opportunistic sightings and not regular surveys. Furthermore, data from different days is not necessarily additive (e.g. may be seeing the same birds on different days). Pre-construction shorebird and waterbird monitoring conducted in 2008 and 2009 confirmed Wilson's plover nesting within the overwash habitat of North Topsail Beach along the New River Inlet, as well as the southern saltmarsh and overwash habitats of Onslow Beach (D. York, pers. comm.).

Table 15
Wilson's Plover Survey Data (1989 to 2004, and 2008 to 2009) for New River Inlet, North Topsail Beach and Onslow Beach, North Carolina (S. Cameron, pers. comm.; D. York, pers. comm.)

Year	Location[a]	Season	Number of Birds Observed[b]	Number of Breeding Pairs
1989	Topsail Beach North	Breeding	2	0
1989	Onslow Beach	Breeding	7	1
1990	NA	NA	NA	NA
1991	Topsail Beach North	Breeding	6	3
1991	Onslow Beach	Breeding	4	2
1992-1999	NA	NA	NA	NA
2000	North Topsail Overwash	Breeding	18	9
2000	Topsail Beach North	Breeding	4	2
2001	North Topsail Overwash	Breeding	14	7
2001	Topsail Beach North	Breeding	4	2
2001	Onslow Beach Overwash	Breeding	6	3
2001	UNI, New River Channel 3	Breeding	4	2
2002	UNI, New River Channel 1	Breeding	4	2
2002	UNI, New River Channel 2	Breeding	2	1
2002	North Topsail Overwash	Breeding	4	2
2002	Topsail Beach North	Breeding	2	1
2002	Topsail Beach North	Fall Migration	3	0

Year	Location[a]	Season	Number of Birds Observed[b]	Number of Breeding Pairs
2003	North Topsail Overwash	Spring Migration	2	0
2003	Topsail Beach North	Breeding	4	2
2003	North Topsail Overwash	Breeding	2	1
2004	Topsail Beach North	Breeding	6	3
2004	UNI, New River Channel 2	Breeding	6	3
2004	Onslow Beach	Breeding	15	7
2008	North Topsail Overwash	Spring Migration	2	NA[1]
2008	Onslow Beach	Spring Migration	7	NA[1]
2008	North Topsail Overwash	Breeding	6	NA[1]
2008	Onslow Beach	Breeding	30	NA[1]
2008	North Topsail Overwash	Fall Migration	35	NA[1]
2008	Onslow	Fall Migration	42	NA[1]
2009	North Topsail Overwash	Spring Migration	43	NA[1]
2009	Onslow	Spring Migration	18	NA[1]
2009	North Topsail Overwash	Breeding	36	NA[1]
2009	Onslow	Breeding	44	NA[1]
		Total	**119**	**53**

[a] Location descriptions provided by observers and NCWRC biologists.
[b] The number of birds observed represent total number of birds surveyed in one season. A large number of observations most likely indicates multiple observations of the same individual.
NA – Indicates no data was available for that particular time period.
NA[1] – Nest locations and breeding pairs was not analyzed as part of the pre-construction monitoring survey conducted in 2008 and 2009 by Coastal Planning & Engineering of NC, Inc.

Gull-Billed Tern

The gull-billed tern (*Sterna nilotica*) is designated by the State of North Carolina as threatened. Gull-billed terns are listed as species of high conservation concern for North America (Kushlan et al. 2002). There is no federal status for this species, and it is considered globally secure (G5 rank). The breeding status of this species in Onslow County is listed as historical (not observed during the last 20 to 50 years) (NCNHP, 2006). However the NCWRC recorded four gull-billed tern nests (Table 16) in the New River Inlet area in 1988 (S. Cameron, pers. comm.). Gull-billed terns have also been observed hawking insects over the flats on the north end of Topsail Beach in recent years (S. Everhart, pers.

comm.). Approximately 34 observations of gull-billed terns were made in 2008 as a result of the pre-construction shorebird and colonial waterbird monitoring program in the New River Inlet complex (D. York, pers. comm.).

Least Tern, Common Tern, Black Skimmer

The least tern (*Sterna antillarum*), common tern (*Sterna hirundo*) and black skimmer (*Rynchops niger*) are designated by the State of North Carolina as Species of Special Concern (species which are determined by the NCWRC to require monitoring). There is no federal status for these species, although the common tern and black skimmer are considered globally secure (G5 rank), while the least tern is ranked as apparently globally secure (G4 rank). Least terns and black skimmers are listed as species of high conservation concern for North America, while common terns seem to be undergoing a decline in the southeast and are therefore listed as a species of regional concern (S. Everhart, pers. comm., Hunter et al. 2001). These species' status is considered current (observed within the last 20 years) in Onslow County (NCNHP, 2006).

Research on the trends of black skimmers, common terns, and gull-billed terns has shown some of the steepest declines in the populations of these species have occurred in North Carolina (S. Cameron, pers. comm.). Fewer suitable nesting sites could make nesting populations vulnerable to catastrophic events. Nest counts were down 50% for common terns and 62% for gull-billed terns from the 2001 survey to the 2004 survey, with the lowest number of common tern nests counted in the history of waterbird surveys in North Carolina. However, black skimmers increased by approximately 5% since the 2001 survey. Cape Hatteras National Seashore continues to support the largest colonies of black skimmers and common terns in the state (Cameron *et al.*, 2004).

Cameron *et al.* (2004) also reported "other early successional nesters appear to be holding their own. Least terns, royal terns, and sandwich terns increased from the 2001 nest count survey. Least terns would likely be displaying downward trends if not for their unique ability to utilize gravel roofs for nesting. In fact, approximately 29% of the state's population of least terns nested on roofs in 2004. While this adaptation has benefited least terns in the short term there is a continued vulnerability resulting in the least terns being listed as a State Species of Special Concern. Least terns continue to nest on barrier island beaches, with the largest colonies located at the north end of Pea Island and Wrightsville Beach with over 300 pairs counted at each site."

Least terns have been observed in or near the Permit Area during the May to June breeding period from 1977 through 2004 (S. Cameron, pers. comm.) as well as from 2008 through 2009 (D. York, pers. comm.). Although regular surveys were conducted in 2008 and 2009 as part of the pre-construction shorebird and colonial waterbird monitoring plan, nest behavior and nest counts

were not conducted. However, as observed by regular surveys, least terns are regular breeders in the Permit Area, with 583 observations made during the 2008 and 2009 breeding season. Least tern colonies did attempt to nest on both Onslow Beach and the overwash area of North Topsail Beach in 2008. It is unknown whether nesting was a success for the colonies. While common terns and black skimmers have historically nested on dredge islands near the mouth of New River, these species also utilize the Permit Area during the non-breeding season (S. Everhart, pers. comm.). The pre-construction monitoring conducted within the New River Inlet complex resulted in approximately 19 observations of common terns in 2008 and 1,131 observations of black skimmers in 2008 and 2009. Table 16 lists the number of nests recorded by the NCWRC between the period of 1977 and 2004 as well as the period of 2008-2009 for the above described species.

American Oystercatcher

American oystercatchers are listed nationally as a species of high conservation concern (Brown et al., 2001; S. Everhart, pers. comm.). However, the American oystercatcher is considered stable globally (G5). Along the western Atlantic coast, the eastern race of the American oystercatcher breeds from Massachusetts to Florida, with the highest concentrations from Virginia to Georgia (Humphrey, 1990). As indicated in Table 17, these species have been observed in or near the Permit Area during the April to June breeding period from 2001 through 2004 as well as from 2008 through 2009 (S. Cameron, pers. comm.; D. York, pers. comm.). Although regular surveys were conducted in 2008 and 2009 as part of the pre-construction shorebird and colonial waterbird monitoring plan, nest behavior and nest counts were not conducted. However, as observed by regular surveys, American Oystercatchers are regular breeders in the Permit Area, with 136 observations made during the 2008 and 2009 breeding season (D. York, pers. comm.).

Table 16
Gull-Billed Tern, Least Tern, Common Tern, and Black Skimmer Survey Data (1977 to 2004; 2008) for the New River Inlet, North Topsail Beach and Onslow Beach (S. Cameron, pers. comm.)

Year	Location[a]	Species	Number of Nests
1977	UNI, New River Channel 2	Common Tern	1
1977	UNI, New River Channel 2	Least Tern	2
1978-1982	NA	NA	NA
1983	UNI, New River Channel 1	Least Tern	39
1983	UNI, New River Channel 2	Common Tern	2

Year	Location[a]	Species	Number of Nests
1983	UNI, New River Channel 2	Least Tern	96
1984-1987	NA	NA	NA
1988	UNI, New River Channel 1	Least Tern	14
1988	UNI, New River Channel 2	Least Tern	5
1988	UNI, New River Channel 3	Black Skimmer	5
1988	UNI, New River Channel 3	Common Tern	14
1988	UNI, New River Channel 3	Gull-billed Tern	4
1988	UNI, New River Channel 3	Least Tern	5
1989	UNI, New River Channel 1	Least Tern	10
1989	UNI, New River Channel 2	Least Tern	4
1990	UNI, New River Channel 2	Common Tern	3
1990	UNI, New River Channel 2	Least Tern	114
1991	New River Inlet, Northside	Least Tern	4
1991	UNI, New River Channel 2	Black Skimmer	25
1992	NA	NA	NA
1993	New River Inlet, Northside	Least Tern	1
1993	UNI, New River Channel 1	Least Tern	1
1994	NA	NA	NA
1995	New River Inlet, Northside	Least Tern	4
1995	UNI, New River Channel 2	Least Tern	33
1996	NA	NA	NA
1997	New Chadwick Bay Inlet	Least Tern	41
1997	Onslow Beach Lifeguard Tower	Least Tern	8
1997	Onslow Beach Overwash	Least Tern	13
1998	NA	NA	NA
1999	New Chadwick Bay Inlet	Least Tern	9
1999	New River Inlet, Northside	Least Tern	7
1999	Onslow Beach Lifeguard Tower	Least Tern	8
1999	UNI, New River Channel 1	Least Tern	2
1999	UNI, New River Channel 2	Least Tern	7
2000	New Chadwick Bay Inlet	Least Tern	110
2001	New Chadwick Bay Inlet	Least Tern	12
2001	Onslow Beach Lifeguard Tower	Least Tern	4
2001	Onslow Beach Overwash	Least Tern	5

Year	Location[a]	Species	Number of Nests
2001	UNI, New River Channel 3	Least Tern	13
2002	New Chadwick Bay Inlet	Least Tern	20
2003	NA	NA	NA
2004	New River Inlet, Northside	Least Tern	2
2004	UNI, New River Channel 2	Least Tern	22
2008	New River Inlet Complex	Least Tern	32
		Total	**701**

[a] Location descriptions provided by NCWRC.
NA – Indicates no data was available for that particular time period.

Table 17
American Oystercatcher Survey Data (2001 to 2004; 2008) for New River Inlet, North Topsail Beach and Onslow Beach (S. Cameron, pers. comm.; D. York, pers. comm.)

Year	Location[a]	Season	Number of Birds	Number of Breeding Pairs
2001	Onslow Beach Overwash	Breeding	2	1
2001	UNI, New River Channel 3	Breeding	4	2
2001	UNI, New River Channel 4	Breeding	2	1
2002	UNI, New River Channel 1	Breeding	2	1
2002	UNI, New River Channel 3	Breeding	2	1
2002	Topsail Beach North	Breeding	2	1
2003	NA	NA	NA	NA
2004	New River Inlet	Breeding	8	4
2004	UNI, New River Channel 2	Breeding	2	1
2004	UNI, New River Channel 3	Breeding	2	1
2008	New River Inlet Complex	NA[1]	136	NA[1]
		Total	**162**	**13**

[a] Location descriptions provided by observers and NCWRC biologists.
N/A – Indicates no data was available for that particular time period.
NA[1] – breeding/nest data was not collected as part of the pre-construction shorebird and colonial waterbird monitoring plan.

Red Knot (*Calidris canutus*)

The red knot, a medium-sized shorebird that has shown alarming population declines in recent years and is a candidate species for federal listing under the Endangered Species Act, is truly a master of long-distance aviation. On wingspans of 20 in, red knots fly more than 9,300 mi from south to north every spring and repeat the trip in reverse every autumn, making this bird one of the

longest-distance migrants in the animal kingdom. Surveys of wintering knots along the coasts of southern Chile and Argentina and during spring migration in Delaware Bay on the U.S. coast indicate a serious population decline.

Red knots' unique life history depends for its success, and the species' survival, on certain conditions. One of the most important is the continued availability of billions of horseshoe crab eggs at major North Atlantic staging areas, notably the Delaware Bay and Cape May peninsula. The increase in taking of horseshoe crabs for bait in commercial fisheries that occurred in the 1990s may be a major factor in the decline in red knots. Another necessary condition for red knots' survival is the continued existence of middle- and high-arctic habitat for breeding. Red knots could be particularly affected by global climate change, which may be greatest at the latitudes where this species breeds and winters.

Rising concern of these birds has led to increased banding and monitoring efforts. Red Knots were observed in Bogue Inlet during the pre- and post-construction shorebird monitoring for the Bogue Inlet Channel Erosion Response Project with the highest number of observations (409) in 2008. Bear Island and Inlet transects provided the most important habitat for this species during most years with the exception of 2005 when birds were equally distributed within the inlet complex. Overall, most birds were observed roosting and foraging, with the predominant activity varying by year, and most were found using intertidal habitats. Peak numbers were typically observed during spring migration, although there were two years (2004 and 2007) with late winter peaks. Pre-construction shorebird monitoring conducted for the North Topsail Beach Shoreline resulted in a total of 198 observations between the period of November 2007 and May 2009. Peak observations were in the spring of 2008 (March-June) with a total of 81 observations. Bogue Inlet and New River Inlet appear to be important migratory staging site for Piping Plovers and Red Knots, especially in the spring.

Eastern Painted Bunting and Other Priority Songbirds

The Eastern painted bunting (*Passerina ciris ciris)* is state listed as Significantly Rare and federally listed as a Species of Special Concern (S. Everhart, pers. comm.). In North Carolina, their breeding habitats are found near saltwater, in a narrow range along coasts and waterways (Audubon North Carolina, 2007) and more specifically, within the Permit Area, in maritime shrub/scrub habitat on North Topsail Beach, Onslow Beach and New River Inlet islands, such as the dredge spoil island proposed to be used for disposal under Alternative 3 (Island 143 located at the junction of New River Inlet and the AIWW). Historical survey data revealed that Eastern painted bunting populations declined at least 3.5% annually over a 30-year period from 1966 to 1995.

Other priority songbird species listed in the NCWRC Wildlife Action Plan (NCWRC 2005), such as sharp-tailed sparrows (*Ammodramus* sp.) and sedge wrens (*Cistothorus platensis*), also utilize the Permit Area (S. Everhart, pers. comm.).

4.2.4 PLANTS

Seabeach Amaranth

Seabeach amaranth (*Amaranthus pumilus*), is an annual plant of Atlantic barrier islands, listed as federally threatened by both the USFWS and the North Carolina Department of Agriculture and Consumer Services. In 1993, Seabeach amaranth had disappeared from the majority of its historic range (Jolls *et al.*, 2003), which included 31 counties in nine different coastal states from Massachusetts to South Carolina. The most up-to-date range-wide reports indicate that seabeach amaranth is found in only one-third of its historic range (USFWS, 1993b). Habitat loss and degradation are the greatest threats to the continued existence of seabeach amaranth with localized herbivory by webworms also contributing to mortality in North Carolina. Though beach stabilization efforts are thought to be a leading contributor to the decrease in the population (USFWS, 1996b), new populations have been observed to follow sand placement on beaches where sand has been disposed by the Corps of Engineers (ex. Wrightsville Beach and Bogue Banks) (CSE, 2001). Seabeach amaranth is dependent on terrestrial, upper beach habitat that is not flooded during the growing season from May into the fall.

Seabeach amaranth is most typically found along sparsely vegetated sand beaches that are tolerant of salt spray, poor soil and low freshwater input. Small populations can occasionally develop along sound-side beaches, blowouts in foredunes, and renourished beaches containing sand and shell material or dredge spoil (USFWS, 1993b). The plant is typically found at elevations from 0.2 to 1.5 m (0.6 to 4.9 ft) above mean high tide (Weakly and Bucher, 1992).

Greatest concentrations of seabeach amaranth occur near inlet areas of barrier islands, but in favorable years many plants may occur away from inlet areas. It is considered a pioneer species of accreting shorelines, stable foredune areas, and overwash fans (Weakly and Bucher, 1992; Hancock and Hosier, 2003). Seed dispersal of seabeach amaranth is achieved in a number of ways, including water and wind dispersal (USFWS, 1995). Flowering begins when plants have reached the appropriate size, and can begin as early as June, but more typically commences in July. The flowering period usually ends in late fall and seed production begins in July or August, reaching its peak in September and continuing until the plant dies back in the winter (USFWS, 2003f).

There are 55 known plant populations, of which 34 are found within North Carolina. North Carolina is considered to be the only state to have large populations of seabeach amaranth and, although the North Carolina populations reached historic lows in 2000 (Jolls *et al*., 2003), the Endangered Species Bulletin (Randall, 2002) reported that the numbers of seabeach amaranth are increasing.

As discussed above, seabeach amaranth grows on barrier island beaches, where it prefers overwash flats at accreting ends of islands and lower foredunes and upper strands of noneroding beaches; these preferred habitats are located on both sides of the New River Inlet. Seabeach amaranth surveys have been performed on the northern 3.8 mi of North Topsail Beach since 1992; however, surveys were not conducted along the southern limits of North Topsail Beach (~8.0 mi) or Surf City (~5.5) mi) until 2006. Based on the available data, a total of 24,369 plants have been recorded throughout the towns of North Topsail Beach and Surf City for all years surveyed. Hurricanes, long term shoreline erosion, and subsequent habitat loss, have likely played a role in the reduction in plant numbers on North Topsail Beach from 2001-2008.

Seabeach amaranth is frequently found in large numbers on Onslow Beach, as 1,797 individual plants were observed there between July 15 and August 15, 2004; 1,670 of those plants (93% of the 2004 population) were found at the extreme south-end of Onslow Beach (within the Permit Area). New River Inlet and the overwash flat consistently harbor the majority of the seabeach amaranth population on Onslow Beach (S. Brewer, pers. comm.). Appendix G includes a map of observed populations on Onslow Beach.

4.3 PERMIT AREA HABITATS

The Permit Area includes a wide diversity of estuarine and nearshore habitat types supporting a diverse ecosystem. The following section describes the primary habitat types found within the Permit Area (Figures 8a – 8c), as well as the flora and fauna located within each habitat. These major habitat types have no defined boundaries; therefore, the possibility of species overlapping with other habitat types exists. Listed in order from onshore to offshore, these habitat types are defined as follows:

1. **Estuarine habitats** in the Permit Area are typically found where freshwater sources meet tidal areas. An estuary is a partly enclosed body of water where freshwater from rivers mixes with saltwater from the sea (NEP, 2007). While there is no distinct boundary, estuarine habitats occur in the Permit Area on both sides of the Inlet complex. Approximately 38 acres may be considered estuarine within the Permit Area as shown in Figure 12a (Environmental Setting Map). Estuarine areas include tributary waters located near Onslow Beach extending from the inlet shoreline to the salt marsh area at the northeastern edge of the

Permit Area. Estuarine habitat also includes the tributary waters extending from the inlet shoreline to the salt marsh area on the North Topsail Beach side.

2. **The New River Inlet Complex** in the Permit Area is approximately 1,219 m (4,000 ft) long with an average width of 27.4 m (90 ft) and an authorized channel depth of -1.8 m (-6.0 ft) MLW. The New River Inlet is highly influenced by tides, and as a result, has higher salinity variation than estuarine habitats. The habitat areas surrounding the New River Inlet include higher, supratidal areas such as upland hammocks. Intertidal flats and shoals are also present within the Inlet complex. Dunes and beaches are adjacent to the inlet complex with the possibility of overlap between habitat types.

3. **Coastal beach and dune habitats** within the Permit Area include the inlet and oceanfront shorelines. The CAMA handbook defines the primary dune as "the first mount of sand (measured from the ocean) that is six ft taller than the mean flood level for the area". Frontal dunes are defined by CAMA as "the first mounds of sand that have enough vegetation, height and continuity to offer protection" (NCDCM, 2006a). Dunes and dune plant species are very important for the stabilizing protection they provide against coastal storms by absorbing the energy from storm waves and providing sand to the beach during periods of erosion. Dunes and the supratidal (i.e. dry) beach also provide shelter and food for a variety of animals and shorebirds as well as areas of recreation for people along the coast. Coastal beach and dune habitats are similar in community composition and ecological function to the dunes and beaches present around the periphery of the Inlet. However, as a result of overwash occurrences, inlet dune and beach habitats are typically not as established as coastal beaches and often lack the vegetation common on the coastal beach and dune systems.

4. **Marine intertidal and subtidal habitats** include the intertidal zone (wet beach) along the inlet and oceanfront shorelines, nearshore softbottom communities, as well as nearshore and offshore hardbottom communities.

Three environmental setting maps (Figures 12a through 12c) illustrate the location and acreage of each habitat type found within the Permit Area.

4.3.1 ESTUARINE HABITATS

While estuaries are also often known as bays, lagoons, harbors, inlets, or sounds, the defining feature of an estuary is the mixing of fresh and saline water (32 to 36 parts per thousand (ppt)). Flush with nutrients and inhabited by resilient organisms, estuaries are among the most productive ecosystems on Earth. They provide rich feeding grounds for coastal fish and migratory birds, and spawning areas for fish and shellfish (NSP, 2007). This section characterizes estuarine communities in the Permit Area including salt marshes and areas where submerged aquatic vegetation has the potential to grow.

4.3.1.1 SALTMARSH COMMUNITIES

In eastern North Carolina, salt marsh communities can be found along 4,500 mi of coastal shoreline, which encompasses 2.1 million acres of estuarine habitat (NCCF, 2007). The relatively low velocity and flat, poorly drained topographic areas found along the North Carolina coastline have provided for the extensive development of these wetlands. These systems are extremely important for filtering water, providing storage during flood events, supplying food and providing habitat for many species. Marsh habitats usually develop on the mainland side of the barrier islands after sand is deposited during storm events. They also develop on the mainland side of the sounds and in the lower reaches of rivers as sea-level rise, salt intrusion or storms kill forested or shrub-scrub habitats.

The CRC has characterized estuarine systems as an Area of Environmental Concern. These areas have been identified as "sensitive and productive coastal lands and waters where uncontrolled development might cause irreversible loss of property, public health and the natural environment" (NCDCM, 2006a). The CRC defines coastal wetlands as "any marsh in the 20 coastal counties that regularly or irregularly floods by lunar or wind tides, and that includes one or more of the 10 plant species" identified by CAMA (NCDCM, 2006a). There are four kinds of coastal marsh habitats found in North Carolina: low marsh, high marsh, brackish marsh, and freshwater marshes.

Low and high marsh environments are regularly and irregularly flooded lands where plant species such as salt marsh cordgrasses (*Spartina alterniflora and S. patens*), glasswort (*Salicornia* spp.), salt grass (*Distichlis spicata*), and sea lavender (*Limonium carolinanum*) may be found. Low salt marsh environments are regularly flooded with the tides and are characterized by organic mats with smooth cordgrass (*Spartina alterniflora*) as the dominant vegetative species. The zonation of vegetation in salt/brackish marsh is largely determined by variations of salinity and drainage of sediment porewater. Some species are restricted in the low marsh because of high porewater salinity, frequent inundation, and high-sulfide porewaters associated with frequent inundation (Street *et al*., 2005). Smooth cordgrass can tolerate a wide range of environmental conditions, including pH levels from 5.4 to 7, salinities from 3 $^{O}/_{OO}$ to 5 $^{O}/_{OO}$, and a water table four inches above ground level (ANHP, 2004).

Cowardin (1979) classifies high marsh as an estuarine intertidal emergent wetland or palustrine, emergent wetland. High salt marsh environments are irregularly flooded lands where plant species such as saltmeadow cordgrass, glasswort, salt (or spike) grass, and sea lavender may be found. Saltmeadow cordgrass grows at the seaward edge of the high marsh, just above the high

water line, providing habitat for a variety of waterfowl and songbirds, as well as other types of wildlife indigenous to the area.

Approximately 72 acres of salt marsh exists within the Permit Area on the sound side (backbarrier marsh) of North Topsail Beach and along the inlet shoreline of Onslow Beach. Approximately 51 acres of marsh exists on the sound side of North Topsail Beach and approximately 21 acres has been identified to the east of the New River Inlet behind Onslow Beach (Refer to Figure 12a). In total, these areas comprise 64 acres of low marsh and eight acres of high salt marsh. The acreage of both low and high marsh habitats has been estimated by remote analysis of the 2005 and 2006 aerial photographs.

Benefits of Salt Marsh Habitats to Shorebirds, Colonial Waterbirds, and other Waterbirds

North Carolina plays a key role in the life cycle of many migratory shorebirds, thus conservation activities directed at shorebird stopover or breeding habitats (primarily beach, dune, estuarine, and coastal marsh habitats) can have a substantial impact on shorebird conservation. Due to their biological productivity, estuaries provide ideal areas for migratory birds to rest and forage during their long migratory journeys. Various species of shorebirds utilize marsh habitats for wintering, as well as feed on fish, shrimp and fiddler crabs found in the salt marsh.

Salt marsh and brackish marsh habitats are important habitat year-round for a variety of rails, bitterns, wading birds and marsh sparrows, several of which are species of conservation concern according to Partners in Flight (Hunter et al. 2000, Pashley et al. 2000, Rich et al. 2004, and Johns 2004). Estuarine communities also provide important habitat for high priority birds during some stage of their life cycle as well as piping plover, Wilson's plover, American oystercatcher, black skimmer, gull-billed tern, bald eagle, peregrine falcon and wood stork.

A variety of other waterbird species that are not classified as shorebirds or colonial waterbirds can also be found utilizing different estuarine habitats. For example, species such as red-breasted mergansers (*Mergus serrator*), clapper rails (*Rallus longirostris*) and ospreys (*Pandion haliaetus*) can be found in and surrounding the New River Inlet. Many waterbirds are piscivorous and forage by surface diving, some are aquatic gleaners, while others are herbivores that feed on submerged aquatic vegetation. These waterbirds can be found in estuaries, marshes, and in the vicinity of New River Inlet year-round or part of the year. However they are mainly present during spring and fall migrations, as well as during the winter.

Benefits of Salt Marsh Habitat to Terrapins

The Carolina diamondback terrapin (species) is the only North American turtle found in brackish waters, and is common in salt marsh environments. Juveniles use matted *Spartina* and other marsh grasses as cover. See Section 4.2.3 for a description of this species.

The marshes behind North Topsail and Onslow Beach provide habitat for diamondback terrapins (H. LeGrand, pers. comm.). According to observations reported to the NCNHP, seven Carolina diamondback terrapin sites were recorded in the marshes behind the western end of Onslow Beach on June 17, 1995 (Appendix G). Data on Carolina diamondback terrapins was received from the NC Natural Heritage Program, as well as the North Carolina Museum of Natural Sciences. However, this data is considered to be outdated (pre 1996) and no observations were recorded within the Permit Area (H. LeGrand, pers. comm.).

Benefits of Salt Marsh Habitats to Fish

Finfish and shellfish using salt/brackish marsh habitats fall into several categories based on location and timing of use (Street *et al*., 2005). Year-round residents of the marsh include small forage species such as killifish (*Fundulus confluentus, F. luciae, F. majalis, Lucania parva*), mummichogs (*Fundulus heteroclitus*), sheepshead minnows (*Cyprinodon variegates*), gobies (*Coryphopterus glaucofraenum, Gobionellus boleosoma, G. hastatus, G. shufeldti, Evorthodus lyricus, Gobiosoma bosci, G. ginsburgi, G. xanthiprora, Microgobius carri, Evermannichthys spongicola*), grass shrimp (*Palaemonetes pugi*), bay anchovies (*Anchoa mitchilli*), and silversides (*Membras martinica, Menidia* spp.). Transient species include those spawning near the marsh, but inhabiting deeper channels (i.e., river herring (*Alosa pseudoharengus*, *A. aestivalis*)), and those spawned in deeper waters using marsh habitat as nursery or foraging areas. Among transient species, some prefer the edge of salt/brackish marsh (i.e., red drum (*Sciaenops ocellatus*), flounder (Family Bothidae, Family Pleuronectidae) while others are found near marsh edge on unvegetated bottom (i.e., spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*). Some species are not found in the marsh, but derive substantial food resources from marsh plants as detritus (i.e., menhaden [*Brevoortia* spp.]) or from microalgae produced on the marsh surface. Of fishery species in North Carolina, penaeid shrimp (*Penaeus duorarum, P. setiferus, P. aztecus*) and red drum are considered critically linked to marsh edge habitat (SAFMC, 1998).

4.3.1.2 SUBMERGED AQUATIC VEGETATION (SAV)

In North Carolina, Submerged Aquatic Vegetation (SAV) is defined as “estuarine waters vegetated with one or more species of submerged vegetation such as

eelgrass (*Zostera marina*), shoalgrass (*Halodule wrightii*) and widgeon grass (*Ruppia maritime*). These vegetation beds occur in both subtidal and intertidal zones and may occur in isolated patches or cover extensive areas" (Street *et al.*, 2005). The Carolinas are in a "transitional area which represents the southernmost extension for some cold-adapted species and the northernmost extension of warm-adapted species. In North Carolina the dominant seagrass, *Zostera marina*, lies at its southernmost extension, while a second species, *Halodule wrightii*, is at its northernmost extent….Seagrass meadows are now much reduced, probably due to elevated nitrogen and increased sedimentation" (Mallin *et al*., 2000), and are limited within the New River Estuary.

Submerged aquatic vegetation is an extremely valuable fish habitat that occurs in North Carolina's coastal estuarine and freshwater systems. Because light is the primary limiting factor affecting its distribution, SAV is restricted to relatively shallow waters. Submerged aquatic vegetation provides ecosystem functions similar to shell bottom, such as enhancing water quality through stabilizing and trapping sediment, reducing wave energy, cycling nutrients within the system, and providing structure for invertebrate attachment and refuge from predators. Seagrasses also produce large quantities of organic matter, which supports a complex food base for coastal fishes and other organisms. This habitat is especially valuable as a nursery and refuge from larger predators for the young of many important commercial and recreational fishery species. Bay scallops, pink shrimp, hard clams, gag, black sea bass, summer flounder, and others are typically associated with high salinity SAV. Juvenile striped bass, striped mullet, brown and white shrimp, Atlantic croaker, and others frequently use low salinity grasses. Red drum and blue crabs are among several species that rely upon both low and high salinity grasses at different stages of their life cycles. The high fisheries value of this habitat has been well established by the scientific community, and SAV is federally designated as a Habitat Area of Particular Concern for penaeid shrimp, blue crab, and red drum. Impacts to high salinity SAV beds could be especially detrimental to bay scallops and black sea bass (south of Hatteras), which are currently listed as overfished. Protection, enhancement, and restoration of this habitat are high priorities for recovery of those species and for sustained health of many others.

The New River is regarded as a blackwater coastal plain river. Unlike most of the large estuaries in North Carolina which are fed by waters originating in the Piedmont Plateau, New River is fed by waters that have drained through the swamps of the coastal plains. This causes the river waters to become darkly stained by the tannins associated with dissolved organic material (Mallin *et al*., 2000). The light attenuation associated with elevated tannin levels and eutrophication is likely one factor contributing to the limited distribution and density of SAV in New River Estuary. In addition, the New River Estuary's transitional nature with respect to cold and warm adapted SAV species places climatic limitations on these species. Resource maps depicting SAV communities along coastal North Carolina do not show SAV communities

occurring within the Permit Area or vicinity of New River Inlet. CPE's coordination with the NCDMF confirmed the absence of SAV in the area based on limited field investigations (A. Deaton, pers. comm.). Additional coordination between CPE and NOAA's Center for Coastal Fisheries and Habitat Research had determined areas of potential SAV occurrence in the Permit Area based on preliminary aerial photo-interpretation (D. Field, pers. comm.). Pre-construction habitat mapping will be conducted and will serve to confirm the presence or absence of SAV habitat within the Permit Area.

Benefits of SAV Areas to Fish

According to North Carolina Division of Marine Fisheries (NCDMF) juvenile abundance survey data, the dominant species in high salinity marsh behind the Outer Banks and Core Sound include pinfish (*Lagodon rhomboides*), pink shrimp (*Farfantepenaeus duorarum*), black sea bass (*Centropristis striata*), gag (*Mycteroperca microlepis*), pigfish (*Orthopristis chrysoptera*), red drum, gulf flounder (*Paralichthys albiggutta*), and summer flounder (*Paralichthys dentatus*), although the primary nursery habitat in these areas is submerged aquatic vegetation. Juvenile spot, brown shrimp, striped mullet (*Mugil cephalus*), and southern flounder (*Paralichthys lethostigma*) are abundant along the western shores of Pamlico and Core sounds and their tributaries (Street *et al*., 2005). Other fish species found in SAV habitat include spadefish (*Chaetodipterus faber*), black sea bass, black margate (*Ansiotremus surinamensis*), black snapper (*Apsilus denataus*), blackfin snapper (*Lutjanus buccanella*), bluestriped grunt (*Haemulon sciurus*), cubera snapper (*Lutjanus cyanopterus*), French grunt (*Haemulon flavolineatum*), graysby (*Epinephelus cruentatus*), jolthead porgy (*Calamus bajonado*), lane snapper (*Lutjanus synagris*), mahogany snapper (*Lutjanus mahogoni*), margate (*Haemulon album*), mutton snapper (*Lutjanus analis*), Nassau grouper (*Epinephelus striatus*), ocean triggerfish (*Canthidermis sufflamem*), red drum, red porgy (*Pagrus pagrus*), saucereye porgy (*Calamus calamus*), schoolmaster (*Lutjanus apodus*), scup (*Stenotomus chrysops*), Spanish mackerel (*Scomberomorus maculates*), spiny lobster (*Panulirus* spp.), white grunt (*Haemulon plumieri*), yellowtail snapper (*Ocyurus chrysurus*) and yellowfin grouper (*Mycteroperca venenosa*). However, as SAV has not been identified in the Permit Area these fish species are not expected to be present in the Permit Area. Refer to Table 18 - Essential Fish Habitat Species.

4.3.1.3 SHELLFISH

The shellfish industry is a large economic industry for North Carolina coastal areas. Three species of shellfish found in coastal waters include eastern oysters (*Crassostrea virginicus*), hard clams (*Mercenaria mercenaria*), and bay scallops (*Argopecten irradians concentricus*).

TABLE 18
ESSENTIAL FISH HABITAT SPECIES OF THE ATLANTIC WATERS
NORTH TOPSAIL BEACH, NORTH CAROLINA

ASMFC - Atlantic States Marine Fisheries Commission;**NCDMF** - North Carolina Division of Marine Fisheries;**NMFS** - National Marine Fisheries Service;**SAFMC** - South Atlantic Fishery Mangement Council;**MAFMC** - Mid-Atlantic Fishery Management Council;
NM - Nautical Mile; / = not likely to occur in area

Taxa	Common Name	Management Designation		NMFS (Highly Migratory Species)	SAFMC (3-200 NM)	MAFMC (3-200 NM)	Probable Life Stage in Project Area	Fish Habitat Ecology	Estuarine Emergent Wetlands	Submerged Aquatic SAV (SAV) and Seagrass Beds	Oyster Reefs and Shell Banks	Intertidal Flats	Estuarine, Marine Water Columns, and Creeks (Subtidal)	Shallow Sand and Muddy Bottoms	Feeding Habits
		ASMFC (0-3 NM)	NCDMF Stock Status (2002)												
Seriola rivoliana	Almaco jack		Concern		X		/	Pelagic; rarely near shoreline, 15 to 160 m (49 to 525 ft); Juv: around floating objects (*Sargassum*)							fish, invertebrates
Chaetodipterus faber	Atlantic spadefish		Concern		X		Juvenile/ Adult	Juv: estuarine, shallow water; Adult: sandy beaches, shallow coastal waters, artificial reefs; 3-35 m (10-115 ft)	X			X	X		invertebrates, plankton
Seriola zonata	Banded rudderfish		Concern		X		Juvenile/ Adult	Coastal waters, inshore around structures, anywhere from surface to seafloor				X	X		fish, shrimps
Centropristis ocyurus	Bank sea bass		Concern		X		/	Hardbottom, shipwrecks to 55 m (180 ft), deep water							small fish, benthic invertebrates
Thunnus obesus	Bigeye tuna			X			/	Oceanic							fish, cephalopods, crustaceans
Myceteroperca bonaci	Black grouper		Concern		X		Juvenile	Adult: offshore, over 18 m (60 ft); Juv: may occur inshore in shallow water				X			fish, cephalopods, crustaceans
Anisotremus surinamensis	Black margate		Concern		X		Juvenile/ Adult	Over rocky bottoms, ledges, wrecks, nearshore reefs, surf areas, around groins					X		crustaceans, urchins, molluscs, fish
Centropristis striatus	Black sea bass	X	Concern		X	X	Juvenile	Adult: Offshore over wrecks, rubble, reefs, rocky bottoms; Juv: estuaries and offshore	X						fish, crustaceans, shellfish
Apsilus dentatus	Black snapper		Concern		X		Juvenile/ Adult	Rocky bottoms; Shallow waters around reefs and SAV		X					fish, cephalopods, tunicates
Lutjanus buccanella	Blackfin snapper		Concern		X		/	Deeper waters over rocky bottoms, near drop-offs and ledges							fish
Callinectes sapidus	Blue crab		Nursery Areas are State designated as geographically defiened EFH				Juvenile/ Adult	Highly migratory; ocean waters, freshwater, sounds, rivers					X		plankton, invertebrates, fish, plants, mollusks, crustaceans, organic debris
Makaira nigricans	Blue marlin			X			/	Oceanic							fish, cephalopods
Haemulon sciurus	Blue stripe grunt		Concern		X		Juvenile	Juv: *Thalassia* beds; Adults: migrate to offshore reefs		X					crustaceans, bivalves, small fish
Thunnus thynnus	Bluefin tuna			X			Juvenile/ Adult	Oceanic, seasonally comes close to shore					X		small schooling fish, squids, red crabs
Pomatomus saltatrix	Bluefish	X	Recovering			X	Juvenile/ Adult	Juv: estuaries, bays, coastal waters Adult: open ocean, large embayments, estuaries	X				X		fish, crustaceans, polychaetes
Caulolatilus microps	Blueline tilefish		Concern		X		Juvenile/ Adult	Surf beaches, estuaries, brackish water, shallow coastal waters	X				X		benthic invertebrates, fish
Scomberomorus regalis	Cero				X		Juvenile/ Adult	Over wrecks, along ledges at depths 1-20 m (3.3 - 66 ft); over coral reefs							crabs, fish, squid
Rachycentron canadum	Cobia				X		Juvenile/ Adult	Over mud, sand, and gravel bottoms, inshore and offshore, estuaries	X			X	X	X	crabs, fish, squid
Cephalopholis fulvus	Coney		Concern		X		/	Shallow and deep water, hides in caves or under ledges							small fish, crustaceans, shrimp
Lutjanus cyanopterus	Cubera snapper		Concern		X		Juvenile	Juv: inshore in SAV; adult: offshore or nearshore over wrecks, reefs, and ledges		X					fish, shrimps, crabs
Lutjanus jocu	Dog snapper		Concern		X		Juvenile	Juv: estuaries, rivers adult: offshore rocky reefs	X				X		fish, benthic invertebrates, gatropods, cephalopods
Coryphaena hippurus	Dolphin fish		Viable		X		Juvenile	Juvs: found near the coast, with floating *Sargassum* ; Pelagic, deep water, close to surface					X		fish, zooplankton, crustaceans, squid
Haemulon flavolineatum	French grunt		Concern		X		Juvenile	Juv: nearshore SAV; Adults: rocky reefs, under ledges		X					small crustaceans
Myceteroperca microlepis	Gag grouper		Recovering		X		Juvenile/ Adult	Juv, larvae: estuaries and SAV; Adults: offshore on rocky bottom, inshore on rocky or SAV bottom	X	X					fish, crabs, shrimp, cephalopods
Chaceon fenneri	Golden crab				X		/	Deep ocean, waters over continental shelf, EFH areas							zooplankton
Lopholatilus chamaeleonticeps	Golden tilefish		Concern		X	X	/	Over mud, rock, sand bottom; continental shelf, 80-540 m (262-1772 ft), ledges							shrimp, crabs, fish, squid, bivalves, holothurians
Epinephelus itajara	Goliath grouper		Concern		X		/	Shallow, inshore areas, rock or mud bottoms, brackish estuaries; not commom north of Florida							crustaceans, turtels, fish, stingrays

TABLE 18 (Cont.)

ESSENTIAL FISH HABITAT SPECIES OF THE ATLANTIC WATERS

NORTH TOPSAIL BEACH, NORTH CAROLINA

ASMFC - Atlantic States Marine Fisheries Commission;**NCDMF** - North Carolina Division of Marine Fishery;**NMFS** - National Marine Fisheries Service;**SAFMC** - South Atlantic Fishery Management Council;**MAFMC** - Mid-Atlantic Fishery Management Council;
NM - Nautical Mile; / = not likely to occur in area

	Common Name	Management Designation		NMFS (Highly Migratory Species)	SAFMC (3-200 NM)	MAFMC (3-200 NM)	Probable Life Stage in Project Area	Fish Habitat Ecology	Estuarine Emergent Wetlands	SAVs	Oyster Reefs and Shell Beds	Intertidal Flats	Estuarine, Marine Water Columns, and Creeks (Subtidal)	Shallow Sand and Muddy Bottoms	Feeding Habits
		ASMFC (0-3 NM)	NCDMF Stock Status (2002)												
Lutjanus griseus	Gray snapper		Concern		X		Juvenile/ Adult	Coastal and offshore waters; rocky areas, estuaries, rivers (juv)	X				X		fish, shrimp, crabs, gastropods, cephalopods, plankton
Balistes capriscus	Gray triggerfish		Concern		X		Juvenile/ Adult	Bays, harbors, lagoons, reefs; Juv: among *Sargassum*					X		benthic invertebrates; mollusks, crustaceans
Cephalopholis cruentatus	Graysby		Concern		X		Juvenile/ Adult	Inhabits SAV (*Thalassia)* beds, coral reefs, rocky reef ledges		X					shrimp, fish
Seriola dumerili	Greater amberjack		Concern		X		Juvenile/ Adult	Deep water, will enter coastal bays					X		fish, invertebrates
Lachnolaimus maximus	Hogfish		Concern		X		Juvenile/ Adult	Over open bottoms or coral reef areas; lagoons					X		molluscs, crabs, sea urchins
Calamus bajonado	Jolthead porgy		Concern		X		Juvenile/ Adult	Coastal waters, vegetated sand bottoms		X			X		sea urchins, crabs, molluscs
Scomberomorus cavalla	King mackerel				X		Juvenile/ Adult	Along beaches and near mouths of inlets and coastal rivers				X	X		fish, penaid shrimp, squid
Calamus nodosus	Knobbed porgy		Concern		X			Over reefs, ledges, wrecks and other hard bottom areas							gastropods, crabs, sea urchins, bivalves, other invertebrates
Lutjanus synagris	Lane snapper		Concern		X		Juvenile/ Adult	Over all types of bottoms, but mainly coral reefs and SAV sandy areas		X				X	fish, crabs, shrimp, worms, gastropods, cephalopods
Seriola fasciata	Lesser amberjack		Concern		X			Coastal pelagic or demersal							squid, fish
Euthynnus alletteratus	Little tunny				X		Juvenile/ Adult	Neritic waters close inshore					X		crustaceans, fish, squid, heteropods, tunicates
Lutjanus mahogoni	Mahogany snapper		Concern		X		Juvenile/ Adult	Shallow waters over rocky bottoms, sandy or SAV areas		X		X		X	fish, shrimps, crabs, cephalopods
Haemulon album	Margate		Concern		X		Juvenile/ Adult	SAV, sand flats, wrecks		X		X		X	benthic and subsurface invertebrates
Epinephelus mystacinus	Misty grouper		Concern		X			Deep water, 100-400 m (328-1312 ft); juv: sometimes 30m (98 ft)							fish, crustaceans, squid
Lophius americanus	Monkfish		Overfished			X	Juvenile/ Adult	Inshore out to depths greater than 800 m (2625 ft); most common in depths 70 to 100 m (230-328 ft)					X		fish, sharks, sea birds
Lutjanus analis	Mutton snapper		Concern		X		Juvenile	Continental Shelf; Adults: among rocks; Juv: over sandy, SAV bottoms		X				X	fish, shrimp, crabs, cephalopods, gastropods
Epinephelus striatus	Nassau grouper		Concern		X		Juvenile/ Adult	From shoreline to at least 90 m (295 ft) depth, close to caves; Juv: SAV		X			X		fish, crabs, crustaceans, molluscs
Canthidermis sufflamen	Ocean triggerfish		Concern		X		Juvenile/ Adult	Over rocky reefs, sand and SAV areas		X				X	benthic invertebrates
Penaeus setiferus	White shrimp		Viable		X		Juvenile/ Adult	Estuarine, palustrine, intertidal marshes and flats, subtidal flats, SAV	X	X		X	X		algae, worms, fish, crabs, other shrimp
Penaeus aztecus	Brown shrimp		Viable		X		Juvenile/ Adult	Estuarine, palustrine, intertidal marshes and flats, subtidal flats, SAV	X	X		X	X		algae, worms, fish, crabs, other shrimp
Penaeus duorarum	Pink shrimp		Viable		X		Juvenile/ Adult	Estuarine, palustrine, intertidal marshes and flats, subtidal flats, SAV	X	X		X	X		algae, worms, fish, crabs, other shrimp
Etelis oculatus	Queen snapper		Concern		X			Offshore over rocky bottoms of continental shelf to 137 m (450 ft)							small fish, squid
Balistes vetula	Queen triggerfish		Concern		X		Juvenile/ Adult	Rocky or coral areas, sand and SAV areas		X				X	benthic invertebrates
Sciaenops ocellatus	Red drum	X	Overfished		X	X	Juvenile/ Adult	Sand and sandy mud bottoms in coastal waters and estuaries; surf zone; oyster reefs and shell banks, SAV	X	X	X		X	X	crustaceans, molluscs, fish
Epinephelus morio	Red grouper		Concern		X		Juvenile/ Adult	Rocky and muddy bottoms; juv: shallow water						X	fish, invertebrates
Epinephelus guttatus	Red hind		Concern		X			Shallow reefs and rocky bottoms; wrecks and ledges; 18 to 110 m (59-361 ft); rare north of Florida							crustaceans, fish, and octopods
Pagrus pagrus	Red porgy		Concern		X		Juvenile/ Adult	Rock, rubble, or sand bottoms; Juv: SAV		X				X	crustaceans, fish, molluscs
Lutjanus campechanus	Red snapper		Concern		X		Juvenile	Rocky bottoms; Juv: shallow waters, over sand or muddy bottoms						X	fish, shrimp, crabs, worms, cephalopods, plankton

TABLE 18 (Cont.)
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	Common Name	Management Designation		NMFS (Highly	SAFMC (3-200 NM)	MAFMC (3-200 NM)	Probable Life Stage in Project Area	Fish Habitat Ecology	Estuarine Emergent Wetlands	SAVs	Oyster Reefs and Shell Beds	Intertidal Flats	Estuarine, Marine Water Columns,	Shallow Sand and Muddy Bottoms	Feeding Habits
		ASMFC (0-3 NM)	NCDMF Stock Status												
Epinephelus adscensionis	Rock hind		Concern		X			Rocky inshore areas or deep reef bottoms, to depths of 76.2 m (250 ft); wrecks, ledges; rare north of Florida							crabs, fish
Centropristis philadelphicus	Rock sea bass		Concern		X			Offshore sandy and muddy bottoms; hardbottom, rocks, jetties, and ledges							invertebrates, fish, squid, plankton, crustaceans
Sicyonia brevirostris	Rock shrimp				X			Sand bottom habitats; 18 -182 m (59-597 ft) in depth							algae, worms, fish, crabs, other shrimp
Istiophorus platypterus	Sailfish			X			Juvenile/ Adult	Oceanic epipelagic; waters close to coasts					X		fish, crustaceans, cephalopods
Calamus calamus	Saucereye porgy		Concern		X		Juvenile	Juv: SAV (*Thalassia)* sandy bottoms; Adults: coral areas		X				X	molluscs, benthic invertebrates, crustaceans
Mycteroperca phenax	Scamp		Concern		X		Juvenile	Adults: deeper waters; inshore and offshore reefs, ledges, *Oculina* coral reefs, depths of 30 to 100m (98-328 ft) in N. Carolina;	X				X		fish, squid, crustaceans
Lutjanus apodus	Schoolmaster		Concern		X		Juvenile	Shallow, clear water over coral reef, near corals / gorgonians; Juv: sand bottoms with or without SAV, muddy bottoms of lagoons,	X	X			X	X	crustaceans, fish, invertebrates
Stenotomus chrysops	Scup	X	Overfished		X	X	Juvenile/ Adult	Intertidal and subtidal habitats, over sand, silty-sand, shell, mud, mussel beds and eelgrss, wrecks, artificial reefs, on or near		X	X	X	X	X	crustaceans, benthic invertebrates, squid, zooplankton, fish
Carcharhinus obscurus	Dusky shark		Overfished	X			Juvenile/ Adult	Surf zone to well offshore; surface to 400 m (1312 ft) depths					X		bony fish, sharks
Carcharhinus brevipinna	Spinner shark		Overfished	X			Juvenile/ Adult	Nearshore to offshore, over continental shelf					X		fish, octopods, squids, cuttlefish, small sharks
Galeocerdo cuvier	Tiger shark		Overfished	X			Juvenile/ Adult	Near surface to depths of 140 m (459 ft), on or adjacent to continental shelves, river estuaries, lagoons	X				X		fish, sharks, rays, marine mammals, sea turtles, seabirds, more
Carcharius taurus	Sand tiger shark		Overfished	X			Juvenile/ Adult	Nearshore from the surf zone, shallow bays to at least 191 m (627 ft) on the outer continental shelves					X		fish, small sharks, rays, squids, crabs, and lobsters
Carcharhinus plumbeus	Sandbar Shark		Overfished	X	X		Juvenile/ Adult	Inshore and offshore, bays, river mouths, harbors					X		bony fish, sharks, cephalopods, shrimp
Rhizoprionodon terraenovae	Atlantic sharpnose		Overfished	X			Juvenile/ Adult	Continental shelves, from the intertidal to deeper waters, surf zone off sandy beaches, estuaries, bays, river mouths	X			X	X		fishes, shrimps, crabs, segmented worms and molluscs
Squalus acanthias	Spiny dogfish	In development	Overfished			X	Juvenile/ Adult	Inshore and offshore, enclosed bys and estuaries, can enter freshwater					X		fish, mollusks, crustaceans, other invertebrates
Archosargus probatocephalus	Sheepshead		Concern		X		Juvenile/ Adult	Bays and Estuaries, brackish water, freshwater, around pilings, jetties	X				X		molluscs, crustaceans
Lutjanus vivanus	Silk snapper		Concern		X			Near edge of continental shelf, deeper waters, below 200 m (656 ft), shallow water at night							fish, crustaceans, gastropods, cephalopods, urochordates
Epinephelus niveatus	Snowy grouper		Concern		X		Juvenile	Adults: well offshore on rocky bottoms, deep as 244 m (800 feet); Juv: can be found inshore							fish, gastropods, cephalopods, brachyuran crustaceans
Paralichthys lethostigma	Southern flounder		Overfished				Juvenile/ Adult	Estuarine dependent, nearshore waters; Juv: inlets, muddy bottoms, estuaries	X			X	X	X	fish, crabs, shrimp
Scomberomorus maculatus	Spanish mackerel	X			X		Juvenile/ Adult	Inshore, nearshore, and offshore, especially over SAV beds and reefs		X			X		fish, shrimp, cephalopods
Epinephelus drummondhayi	Speckled hind		Concern		X			Offshore rocky bottoms, common between 60 and 120 m (197 and 394 ft)							fish, crabs, shrimp, molluscs
Panulirus argus	Spiny lobster				X		Juvenile/ Adult	Oceanic, shallow subtidal, seagrass, unconsolidated bottom, *Laurencia* algal communities, coral live hardbottom		X			X	X	benthic scavengers
Paralichthys dentatus	Summer flounder	X	Recovering			X	Juvenile/ Adult	Estuarine dependent, coastal waters; Juv: inlets, sandy bottoms in higher-salinity areas of estuaries	X	X		X	X	X	fish and shrimp
Xiphias gladius	Swordfish			X			Juvenile/ Adult	Oceanic but sometimes found in coastal waters					X		fish, crustaceans, squid
Mycteroperca tigris	Tiger grouper		Concern		X			Coral reefs and rocky areas							fish, crustaceans
Haemulon aurolineatum	Tomtate		Concern		X		Juvenile/ Adult	SAV, sand flats, and patch reefs		X		X		X	crustaceans, molluscs and other invertebrates, plankton, algae
Rhomboplites aurorubens	Vermilion snapper		Concern		X			Moderately deep waters, over rock, gravel or sand bottoms near edge of cont. shelf; Juv: shallower depths below 25 m (82 ft)							fish, shrimp, crabs, benthic invert, cephalopods, plankton
Acanthocybium Solanderi	Wahoo		Viable		X		Juvenile/ Adult	Oceanic, epipelagic, coastal					X		fish, squid
Epinephelus nigritus	Warsaw grouper		Concern		X			Rocky bottoms; Juv: jetties, shallow reefs							crabs, shrimp, lobster, fish
Cynoscion regalis	Weakfish	X	Viable				Juvenile/ Adult	Shallow water over sand, sandy mud bottoms; in summer move to river estuaries	X			X	X	X	crustaceans, fish

TABLE 18 (Cont.)
ESSENTIAL FISH HABITAT SPECIES OF THE ATLANTIC WATERS
NORTH TOPSAIL BEACH, NORTH CAROLINA

ASMFC - Atlantic States Marine Fisheries Commission;**NCDMF** - North Carolina Division of Marine Fisheries;**NMFS** - National Marine Fisheries Service;**SAFMC** - South Atlantic Fishery Mangement Council;**MAFMC** - Mid-Atlantic Fishery Management Council;

NM - Nautical Mile; / = not likely to occur in area

Haemulon plumieri	White grunt		Concern		X		Juvenile/ Adult	Adults: patch reefs, coral heads, sandy bottoms; Juv: SAV (*Thalassia*)		X				X	crustaceans, fish, molluscs
Tetrapturus albidus	White marlin			X				Deep water, over 100 m (328 ft)							fish, squid
Calamus leucosteus	Whitebone porgy		Concern		X			Fairly deep water, 10-100 m (33-328 ft), over rocks, reefs or patchy bottom							crustaceans, molluscs
Polyprion americanus	Wreckfish		Concern		X			Inhabit caves and shipwrecks; Juv: congregate below floating objects							crustaceans, cephalopods and benthic fishes
Mycteroperca venenosa	Yellowfin grouper		Concern		X		Juvenile/ Adult	Juv: shallow SAV (*Thalassia*) beds; Adults: rocky and coral reefs, mud bottoms, 2 to 137 m (6.6-450 ft)		X					fish, squid
Thunnus albacares	Yellowfin tuna			X				Oceanic							fish, crustaceans, squid
Mycteroperca interstitialis	Yellowmouth grouper		Concern		X		Juv/Sm Adult	Rocky or coral bottoms from shoreline to at least 55 m (509 ft) depth; smaller fish: lagoons					X		fish
Ocyrus chrysurus	Yellowtail snapper		Concern		X		Juvenile/ Adult	Coastal water, coral reefs; Juv: SAV		X			X		plankton, fish, crustaceans, worms, gastropods, cephalopods

Shellfish are also an important resource in New River Inlet. The structures that shellfish create, such as beds and reefs, are used by many species of fish and invertebrates (Burrel, 1986). The South Atlantic Fishery Management Council (SAFMC) defines this habitat as "the natural structures found between (intertidal) and beneath (subtidal) tide lines, that are composed of oyster shell, live oysters and other organisms that are discrete, contiguous and clearly distinguishable from scattered oysters in marshes and mudflats, and from wave-formed shell windrows" (SAFMC, 1998). Common terms used to describe shell bottom habitats in North Carolina are "oyster beds," "oyster rocks," "oyster reefs," "oyster bars," and "shell hash." Shell hash is a mixture of sand or mud with gravel and/or unconsolidated broken shell (clam, oyster, scallop, and/or other shellfish).

Extensive intertidal oyster rocks occur in North Carolina's southern estuaries, where the lunar tidal ranges are higher. The New River is a good example of shell hash habitat (Street *et al*., 2005). The SAFMC has designated oyster reefs as Essential Fish Habitat (EFH) for red drum (NMFS, 1999). The NCDMF differentiates potential shellfish habitat by strata types, in which designated strata types are as follows: "D" – Subtidal Soft Non-vegetated without shell, "H" – Subtidal Firm Non-vegetated without shell, "L" – Subtidal Hard Non-vegetated without shell, "V" – Intertidal Hard Vegetated (marsh grass or SAV) without shell, "W" – Intertidal Hard Non-vegetated shell, and "X" – Intertidal Hard Non-vegetated without shell (Caroon, pers. comm.).

The NCDMF Shellfish Mapping Program has mapped the general location of shellfish habitats, and have identified strata W (intertidal hard, non-vegetated, with shell) and strata V (intertidal hard, vegetated without shell) in and around the New River Inlet where oysters and hard clams can be found (Caroon, pers. comm.; Conrad, pers. comm.). Benthic habitat surveys were conducted in 1991 and 1992 by the NCDMF (Conrad, pers. comm.). Figures 14 and 15, created by the NCDMF Shellfish Mapping Program, illustrate shellfish maps based on the data collected. The number (in bushels) of hard clams (*Mercenaria mercenaria*), oysters (*Crassostrea virginica*), and bay scallops (*Argopecten irradians*) present when these surveys were conducted by the NCDMF Shellfish Mapping Program are listed in Tables 19 and 20. While the 1992 data does not confirm the absence of shellfish in the Permit Area, it does confirm that none were found at the time of sampling and that most of the Permit Area is absent of potential shellfish habitat. According to Map S061 (Figure 14) strata type L (subtidal hard non-vegetated w/o shell) was identified as the dominant strata type within the New River Inlet. Figure 15, Map SO67 identifies strata type X (intertidal hard non-vegetated w/o shell) as an additional primary habitat within the Permit Area of New River Inlet. Strata type L and X provides potential habitat for shellfish (clams, oysters or scallops) (Conrad, pers. comm.).

Hard Clams

According to the NCDMF, the stock status of hard clams (*Mercenaria mercenaria*) is unknown because there is no data available to assess the population size (NCDMF, 2001a). Hard clams are an estuarine-dependent mollusk found primarily in sandy and vegetated bottoms and increased fishing, poor water quality, and habitat loss have impacted this fishery (NCDMF, 2003c). The EFH for the hard clam, as designated by the SAFMC, is subtidal and intertidal flats, oyster reefs and shell banks, and SAV (NCDMF, 2001). A State Fishery Management Plan was approved for the hard clam in August 2001.

Hard clams are suspension feeders that feed primarily on phytoplankton. They spawn from May through November, when water temperatures reach 20ºC (68°F). When hard clam larvae settle to the bottom, it uses its muscular foot to dig into the substrate, and secretes a calcium carbonate shell. Hard clams can be found in nearly all of the sheltered marine waters of North Carolina. Based on research examining clam landings per trip, the NCDMF found that the harvest of clams appeared to be particularly stable (NCDMF, 2001). While no hard clams were present in the Permit Area during the 1992 surveys conducted by NCDMF, the 1994 and 1995 surveys found one bushel of clams in strata type L. Strata type L was identified both inside and outside the Permit Area; as a result the presence of hard clams in the Permit Area has not been confirmed by NCDMF.

Eastern Oysters

Eastern oysters (*Crassostrea virginica*) are long-lived (approximately 40 years) and are capable of forming large reefs. According to the NCDMF, the eastern oyster has a stock status designation of concern, due to a long-term decline most likely caused by over harvesting, habitat disturbances, and pollution. Oysters, SAV, and benthic microalgae quickly process dissolved and suspended material from the water column, thus facilitating the estuaries' role in storage and cycling of nutrients. This process reduces the likelihood of coastal eutrophication and its detrimental effects on fish and fisheries. Oyster beds also increase shoreline complexity, can alter circulation patterns, and enhance fish use of marsh edge habitat.

Oysters require a relatively clean, firm substrate to attach to and can be found in intertidal or subtidal estuarine environments. Spawning in North Carolina occurs from May through September. Vast intertidal reefs formed by oysters are significant biological and physical formations in the estuaries of North Carolina. Fish, crabs, and shrimp utilize oyster beds as refuge and as a source of food. The intertidal oyster beds also provide habitat for various infaunal and epifaunal species.

The eastern oyster is a very successful estuarine bivalve and can tolerate a wide variety of salinities, temperatures, currents, and turbidities. *C. virginica* can thrive in the most rigorous of habitats (Burrel, 1986). The preferred habitat for eastern oysters is from just below MLW to one m (3.28 ft) above MLW (Burrel, 1986). The eastern oyster is a prolific bivalve, whose stocks have been depleted, which identified a need for a State Fishery Management Plan (adopted in August of 2001) in parallel with the Hard Clam Fishery Management Plan.

No oysters were present in the Permit Area during the 1992, 1994 and 1995 surveys conducted by NCDMF.

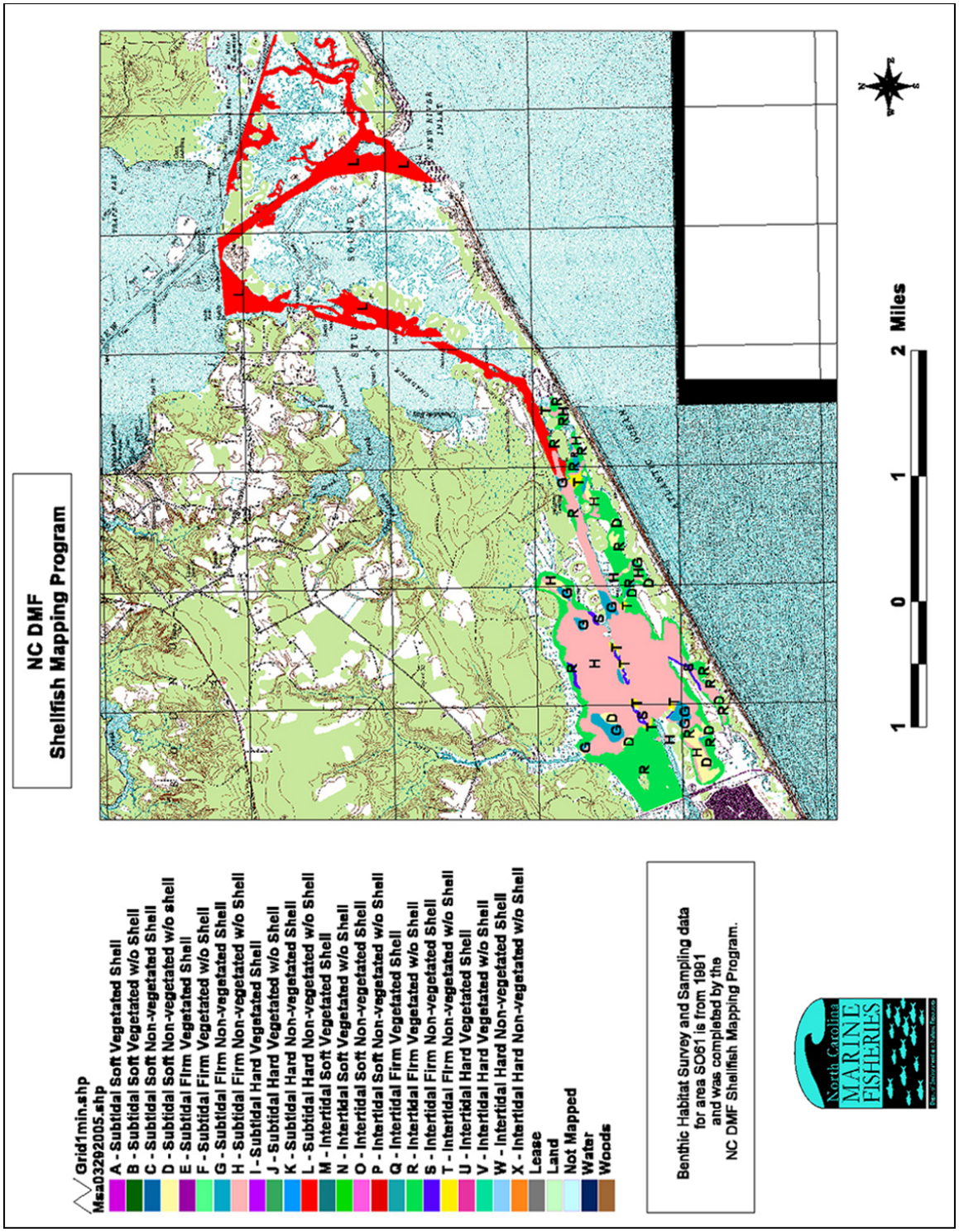

Figure 14 NCDMF Shellfish Mapping Program – Area SO61

Table 19
Shellfish Density Data for Area SO61. Surveys conducted by NCDMF between December 1994 and March 1995

Strata	Number of Samples	Area Sampled (Square meters)	Collection Number	Density (Shellfish per square meter)
S061				
		CLAM		
D	15	13.50	0.00	0.00
G	15	13.50	39.00	2.89
H	36	32.40	11.00	0.34
L	15	13.50	1.00	0.07
R	15	15.00	0.00	0.00
S	32	32.00	55.00	1.72
T	15	15.00	3.00	0.20
		OYSTER		
D	15	13.50	0.00	0.00
G	15	13.50	50.00	3.70
H	36	32.40	3.00	0.09
L	15	13.50	0.00	0.00
R	15	15.00	0.00	0.00
S	32	32.00	1,622.00	50.69
T	15	15.00	55.00	3.67
		SCALLOP		
D	15	13.50	0.00	0.00
G	15	13.50	0.00	0.00
H	36	32.40	0.00	0.00
L	15	13.50	0.00	0.00
R	15	15.00	0.00	0.00
S	32	32.00	0.00	0.00
T	15	15.00	0.00	0.00

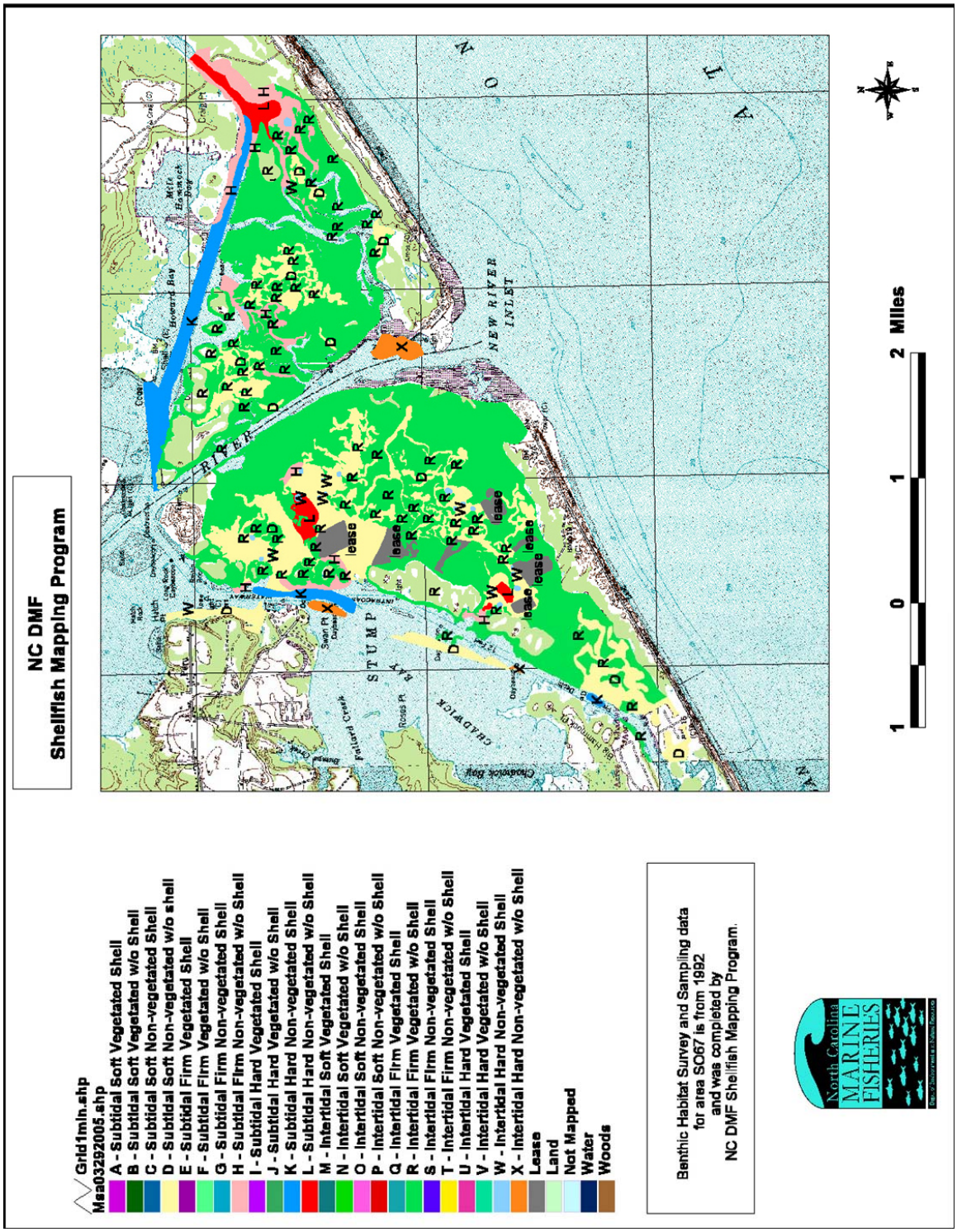

Figure 15 Shellfish Mapping Program – Area SO67

Table 20
Shellfish Density Data for Area SO67. Surveys conducted by NCDMF Shellfish Mapping Program between August 1992 and October 1992

Strata	Number of Samples	Area Sampled (Square meters)	Collection Number	Density (Shellfish per square meter)
S067				
		CLAM		
D	15	15.00	0.00	0.00
H	15	15.00	0.00	0.00
K	15	13.50	0.00	0.00
L	15	13.50	0.00	0.00
R	15	15.00	0.00	0.00
W	67	67.00	0.00	0.00
X	15	13.50	0.00	0.00
		OYSTER		
D	15	15.00	0.00	0.00
H	15	15.00	0.00	0.00
K	15	13.50	0.00	0.00
L	15	13.50	0.00	0.00
R	15	15.00	0.00	0.00
W	67	67.00	3,016.00	45.01
X	15	13.50	0.00	0.00
		SCALLOP		
D	15	15.00	0.00	0.00
H	15	15.00	0.00	0.00
K	15	13.50	0.00	0.00
L	15	13.50	0.00	0.00
R	15	15.00	0.00	0.00
W	67	67.00	0.00	0.00
X	15	13.50	0.00	0.00

Bay Scallop

The NCDMF lists the Bay Scallop (*Argopecten irradians*) as a species of concern based on poor recruitment and low abundances. However, the NCDMF has not yet developed a fisheries management plan for the Bay Scallop. *A. irradians* is an estuarine dependent bivalve found in seagrass (mainly eelgrass) beds. Bay scallops are rarely found attached, although they do have the ability to attach by byssal threads mainly as juveniles but as they mature, scallops sink to the bottom and continue to grow (Fay *et al*., 1983). Adult scallops prefer calm waters, secluded from high winds, storms, with tides and depths of 0.3 to 10 m (98 to 32.8 ft). Environmental factors, such as temperature and rainfall, play a critical part in scallop abundance (NCDMF, 2003a). They spawn between August and December when water temperatures are approximately 15.5°C (60ºF). Bay scallops are filter feeders that feed on diatoms. In coarse sand substrates, shallow burrowing may be used during feeding. Soft mud and silt substrates are harmful to juvenile survival, only if the juveniles are not first attached directly to seagrass for a short period of growth before dropping to the bottom (Fay *et al*., 1983). Bay scallops are short-lived, living generally less than 26 months.

Shellfish require optimal temperature, salinity, and water current to ensure proper development and survival. The eastern oyster is a more resistant shellfish than hard clams or bay scallops. Oysters can tolerate a wide variety of temperature, currents and salinities. As a general rule, eastern oysters require temperatures above 19.5ºC (66.2°F) for egg development, above 20°C (68°F) for larval development, and 10 to 30ºC (50 to 86°F) or higher for adult growth. Optimal salinities for egg development of *Crassostrea virginicus* are from 10 to 22 ppt; for larvae development, 5 to 39 ppt; and for growth, 25 to 29 ppt. Optimal environmental conditions for the bay scallop are temperatures that range from 26 to 28ºC (78.8 to 82.4°F) for egg survival, and 20 or 25ºC (68 or 77°F) for normal development, paired with salinities of 25 ppt (Fay *et al*., 1983). Growth of hard clam larvae is quickest at temperatures found between 22.5 and 36.5ºC (72.5 and 97.9°F) with salinities of 21.5 to 30.0 ppt (Eversole, 1987). Research on growth of adult hard clams found that growth of adults was fastest at 20ºC (68°F) and stopped below 9ºC (48.2°F) and above 31ºC (87.8°F). Salinities above 25 ppt significantly affect normal embryonic development while temperatures too low will not allow maturation and spawning (Eversole, 1987). No scallops were present during the 1992, 1994 and 1995 surveys conducted by the NCDMF. However habitat with the potential to support scallops was identified within the Permit Area.

Benefits of Shellfish Habitats Areas to Fish

Shell bottom provides critical fisheries habitat not only for oysters, but also for recreationally and commercially important finfish, other mollusks, and crustaceans. Shell bottom provides hard structure for attachment of diverse invertebrate species and protective cover for small mobile finfish and invertebrates. Gobies, blennies, hard clams, mud crabs, blue crabs, anchovies, oyster toadfish, and sheepshead are a few of the typical residents of oyster reefs. Research has shown that abundance and production of numerous fishery and prey species are enhanced more by shell bottom than by the surrounding soft bottom. Some of the important fishery species whose production is enhanced by shell bottom include hard clam, black sea bass, gag, tautog, and southern flounder. Shell bottom is federally designated as a Habitat Area of Particular Concern for estuarine dependent snapper-grouper species. The restoration of living oyster beds is therefore critical to the proper functioning and protection of surrounding coastal fish habitats and numerous fishery species.

The ecological functions of oyster reefs related to oyster production are well known and accepted. These functions include aggregation of spawning stock, chemical cues for successful spat settlement, and refuge from predators and siltation. Oysters have also been described as “ecosystem engineers” that create reef habitat important to estuarine biodiversity and fishery production. Several studies have found higher abundance and diversity of fish on shell bottom than adjacent softbottom, particularly pinfish, blue crabs (*Callinectes sapidus*), and grass shrimp (Street *et al*., 2005).

4.3.2 INLET COMPLEX

The inlets of North Carolina are dominated by wave and tidal processes, often with large flood tidal deltas. These inlets historically migrated along the Outer Banks and were typically created by storm breaching. Many are now maintained by the USACE for navigation purposes. The New River is part of the White Oak River basin, although the Inlet itself has been substantially altered by anthropogenic activities. These activities include the construction and maintenance of several navigation channels, such as the AIWW, and the Inlet channel connecting the AIWW with the Atlantic Ocean through the ebb tide delta. The New River Inlet is a dynamic environment, and the Inlet channel and AIWW undergo periodic maintenance dredging by the USACE to remove the littoral sediments accreting in the Inlet channel and shoaling in the AIWW. The Inlet has experienced significant shoaling during the past decade due to sand deposition in backbarrier tidal creeks, and ephemeral islands and shoals continue to form and migrate within the delta. Changes in sea level due to global warming continue to be of potential concern; a slight increase in global temperature could be enough to raise water levels to the point that many coastal wetland areas would be destroyed (USFWS, 2007e).

The New River Inlet complex has various habitat types. The backbarrier region consists mostly of salt marsh, as described in Section 4.3.1.1. Therefore, due to habitat utilization overlap, species present in the salt marsh habitats may also utilize other habitats in the inlet complex. Higher, supratidal areas found in the inlet complex contain upland hammock areas, whereas intertidal flats and shoals present within the Inlet are shallow and unvegetated. While dunes and beaches also line the inlet complex, these habitats are discussed separately in Section 4.3.3. As these habitat types are in proximity to each other within the Permit Area, species common to inlet beaches will also utilize coastal dunes, consequently species overlap among different habitats occurs.

Benefits of Inlet Complex Habitats to Shorebirds, Colonial Waterbirds, and Other Waterbirds

The New River Inlet complex is heavily used by non-breeding migrating and wintering shorebirds. Most shorebirds are long-distance migrants, who migrate through and winter in North Carolina en route to find suitable breeding sites in the Artic. To complete these flights, shorebirds must obtain large fat reserves. New River Inlet is one of many North American, food-rich, migration stop-over areas used by shorebirds to replenish food reserves and accumulate fat needed for the long flights. There are few places that have the necessary combination of resources, in some areas between 50% and 80% of the entire population of a species may visit a single site (MCCS, 2003). Migratory Artic bound shorebird species that may be found during non-breeding season at New River Inlet include red knot (*Calidris canutus rufa*), dunlin (*Calidris alpine)*, western sandpiper (*Calidris mauri)*, and sanderlings (*Calidris alba*). Many Artic breeding species are experiencing declines including the red knot, which was recently listed as a candidate for protection under the Endangered Species Act (S. Everhart, pers. comm.).

Renourishment can have negative effects on turtle and bird nesting, and on the invertebrate food base of shorebirds. Other methods of beach stabilization, such as relocating inlets and preventing natural inlets from migrating, are also becoming more common. These activities can also have deleterious effects on early successional beach nesting birds by preventing spit formation and overwash and leading to increased vegetation. As development increases along the coastline, many non-native plants and animals proliferate and become problematic. Raccoons, foxes, and feral cats that were historically absent from most of the barrier islands are now taking advantage of trash dumps, fish bait and other food sources left behind by humans. These animals are particularly adept at finding and eating beach nesting bird chicks and eggs, and turtle hatchlings and eggs. Coastal development and human activity have limited the availability of some of these habitat areas. The ‘Outer Banks’ of North Carolina

constitute a prime example of a potentially important area for which only limited information on migratory birds is available (Dinsmore, *et al*., 1998).

Colonial waterbirds that utilize the inlet complex include terns (*Sterna* spp.), black skimmers (*Rynchops niger*), herons, egrets (Family Ardeidae), gulls (*Larus* spp.), ibis (Family Threskiornithidae), and pelicans (*Pelecanus occidentalis*) (S. Cameron, pers. comm.). Wading birds include herons and egrets, and ibises (*Threskiomis* spp.) that primarily feed by wading in shallow waters. These species have been recorded in the inlet complex (S. Cameron, pers. comm.).

Other species of waterbirds that are not classified as shorebirds or colonial waterbirds utilize the inlet complex habitats. For example, species such as red-breasted mergansers (*Mergus serrator*), clapper rails (*Rallus longirostris*) and ospreys (*Pandion haliaetus*) utilize the different habitats in and surrounding New River Inlet. These waterbirds can be found in inlet areas of New River Inlet year-round or part of the year, but are present in the area mainly during spring and fall migrations, as well as during the winter.

The 2005 Camp Lejeune Christmas Bird Count listed multiple species of loons (*Gavia* spp.) and mergansers in the Permit Area although no clapper rails or ospreys were observed (See Appendix G for records of bird counts).

Migrating breeding species observed in the New River Inlet vicinity include piping plovers and Wilson's plovers (S. Everhart, pers. comm.). Refer to Section 4.2.4 for a full description of these species and the pertinent habitats utilized during breeding and non-breeding seasons.

Benefits of Inlet Complex Habitats to Fish

The various habitats found in the Inlet Complex provides fisheries habitat, foraging grounds, and spawning grounds. Penaeid shrimp are reported to spawn offshore, moving into estuaries during post-larval stage during the early spring. As the shrimp grow larger in size, they migrate to higher salinity environments. Come late summer and fall, they return to the ocean to spawn (NCDMF, 2005a). It is during the July through October period that approximately 77% of the North Carolina shrimp harvest (for all waters) is landed, 66% of which is taken from ocean sub-areas < 3 mi offshore and south of Cape Hatteras (NCDMF, 2005). In a NCDMF juvenile brown, white and pink shrimp sampling program (1999 – 2003) the majority of shrimp were "collected in close proximity to shallow wetland systems." In the vicinity of the Project Area it was found that brown shrimp concentrations were higher in Stump Sound, while white and pink shrimp were mostly concentrated in New River (NCDMF, 2005a).

Brown Shrimp
Brown shrimp spawn in the deep ocean during February and March. Larval immigration to estuaries peaks from mid-March through mid-April. Brown shrimp prefer peat and muddy bottoms as habitat (NCDMF, 2005a).

Pink Shrimp
Pink shrimp spawn in ocean waters from April to July. Post larvae immigrate to estuaries from May to November. Juvenile pink shrimp are reported to over-winter in North Carolina estuaries. Pink shrimp prefer foraging in shallow waters among marine plants. They are nocturnal feeders but may feed during the day in turbid water (NCDMF, 2005a).

White Shrimp
White shrimp spawn at depths greater than 30 ft in the ocean from March to November. Post larvae immigrate to estuaries two to three weeks after hatching when they become benthic. Juvenile white shrimp prefer muddy bottoms in low to moderate salinity estuarine waters and brackish waters. White shrimp migrate south from estuaries during fall and early winter. "Some of the slower-growing individuals overwinter in the estuaries, but usually do not survive in North Carolina" (NCDMF, 2005a).

Blue Crab
Blue crab migration and movement are seasonal and depend on parameters such as life stage, sex, temperature and salinity. Research indicates that "juvenile blue crabs have wide distributions, but they are most abundant in middle and upper estuarine waters of low to intermediate salinity…. Optimum sediment for small crabs is detritus, mud, or mud-shell bottom….Subtidal sand and mud bottoms have been documented as overwintering habitat for juvenile blue crabs…Small creeks and rivers in and around salt marshes provide shallow-water habitats for larger juveniles and mature crabs for feeding and refuge during molting" (NCDMF, 2004). The blue crab fishery is North Carolina's most valuable commercial fishery (NCDMF, 2005a).

Blue crabs mate from May through October in the upper areas of estuaries and lower portions of rivers. Mated females then migrate to higher salinity waters in lower reaches of estuaries and sounds where they spawn and overwinter. In North Carolina, spawning occurs from March through October. Blue crab eggs are reported to require 23 – 33 ppt salinity at temperatures between 19^0C (66^0F) and 29^0C (84^0F) for hatching (Blue Crab Archives, 2006).

Red Drum
Red drum spawning occurs in the fall (August through October) in estuaries and around coastal inlets with optimal temperatures being between 22^0C and 30^0C (72^0F to 86^0F) (RDFMPAC and NCDMF, 2001; NCDMF 2005b). "In North Carolina, spawning adults were reported to be common in salinities above 25 ppt

in Bogue Sound and the Cape Fear River. Spawning adults were present but not frequently encountered in Pamlico Sound and the New River" (ASMFC, 2002). The ELMR database for the New River Estuary indicates red drum adults are rare from March through November and not present December through February (NOAA, 2005).

Larvae are recorded in the ELMR database as rare during July through October in the New River Estuary. They are recorded as not present from November through June. Juvenile abundance in SAV beds can vary seasonally or spatially, being more common in the summer or where located close to spawning areas (RDFMPAC and NCDMF, 2001). The ELMR database indicates juveniles are common year-round at salinities ranging from 5 to > 25 ppt and rare at salinities < 5 ppt (NOAA, 2005). Juveniles are reported to prefer shallow shorelines of bays and rivers and shallow grass flats in the sounds (RDFMPAC and NCDMF, 2001).

Southern flounder

Southern flounder (*Paralichthys lethostigma*) is managed by the North Carolina Division of Marine Fisheries through an FMP developed in February 2005. It is not currently Federally managed. This species has adapted to a wide range of habitats in estuarine and oceanic environments (NCDMF, 2005b). Adult southern flounder emigrate from rivers and estuaries between November and February where they spawn offshore (December through March) in warmer Gulf Stream waters. After spawning, adults return to the estuaries of North Carolina (NCDMF, 2005b). Optimal conditions for egg hatching, larval development and survival occur between 17^0 C and 21^0C (63^0F and 70^0F) which is consistent with the temperature of Gulf Stream influenced water during the spawning season. Larval flounder develop during a 30 to 60 day period in these offshore waters, and following metamorphosis, are carried through the inlets into estuaries. After settling on tidal flats in the upper reaches of estuaries, the juveniles migrate to riverine habitats (NCDMF, 2005b).

4.3.2.1 UPLAND HAMMOCK

Maritime upland hammocks are typically isolated and flooded by storm surges. These forested systems are typically dominated by live oak (*Quercus virginiana*), loblolly pine (*Pinus taeda*), and red cedar (*Juniperus virginiana*) trees with an understory of shrub thicket which can support such species as swamp bay (*Persea palustris*) and sweetbay (*Magnolia virginiana*). Estuarine forested wetlands are common in the upper estuarine regions of coastal rivers (Street *et al*., 2005). The dominant wind direction and influence of salt spray is usually evidenced by the sculpted vegetation (USC, 2002; Texas Cooperative Research Unit, 2002).

Benefits of Upland Hammocks to Colonial Waterbirds

Colonial waterbirds utilize a variety of habitats for foraging, roosting, and nesting. Some colonial waterbirds such as herons, and egrets utilize vegetated, upland environments. These colonial waterbird groups prefer trees, shrubs, and grass lands for nesting and, as a result, may utilize the upland hammocks identified within the Permit Area.

4.3.2.2 INLET DUNES, BEACHES AND OVERWASH AREAS

This section identifies and discusses the dune and beach communities within New River Inlet. These habitats are present around the periphery of the Inlet and are similar in community composition and ecological function as the oceanfront dunes and beaches. However, these habitats are typically not as established as coastal beaches and often lack the vegetation common on the coastal beach and dune systems, as a result of overwash occurrences.

Sea Level Rise

Geologic evidence suggests global sea level has fallen and risen with minimums and maximums occurring during cold glacial and inter-glacial warm periods respectively. During the last inter-glacial period, about 125,000 years ago, sea level was 4m to 6m higher than at present. The earth entered the present inter-glacial warm period following the peak of the last Ice Age about 12,000 years ago (CCSP 2009). After a rapid initial rise, Global Mean Sea Level (GMSL) is interpreted as having approximately stabilized within a meter or so of its present value over the last several thousand years (NRC 1987, IPCC 2007). IPCC (2007) concludes that global mean sea level rose at an average rate of about 1.7 ± 0.5 mm/year during the twentieth century. Recent climate research has documented global warming during the 20th Century, and has predicted either continued or accelerated global warming for the 21st Century and possibly beyond (IPCC 2007). One impact of continued or accelerated climate warming is thus continued or accelerated rise of GMSL.

Sea-level change can cause a number of impacts in coastal and estuarine zones, including changes in shoreline erosion, inundation or exposure of low-lying coastal areas, changes in storm and flood damages, shifts in extent and distribution of wetlands and other coastal habitats, changes to groundwater levels, and alterations to salinity intrusion into estuaries and groundwater systems (e.g., CCSP 2009).

The impacts of historic rates of rise in sea level are implicitly included in the historic shoreline change data used to formulate the shoreline and inlet management plan for North Topsail Beach. The historic rate of rise in sea level applicable to the project area is 1.25 feet per century. Some projections suggest the rate of sea level rise could double within the next 50 to 100 years however

since only a portion of the observed shoreline change rates are associated with sea level rise, doubling the rate of shoreline change associated with sea level.

An example of how sea level rise may or may not affect the performance of a beach nourishment project, the Wrightsville Beach and Carolina Beach federal storm damage reduction projects can be evaluated. Both of these project have been in existence since 1965 (44 years) and have been subjected to the same rate of sea level rise applicable to North Topsail Beach. A review of the nourishment rates for these two projects shows no significant change in the volume or frequency of periodic nourishment needed to maintain the projects.

Overwash Habitats

Natural processes, such as storms, create overwash features usually behind primary sand dune areas. Overwash areas are usually created during strong storm events when tides wash over portions of the beach and move sand back towards the sound, creating new habitat. Island overwash is an important natural process in maintaining coastal barrier islands. Large man-made dunes may limit the occurrence of overwash features. When overwash occurs, the net volume of sand is often maintained and the island migrates landward (Donnelly *et al.,* 2006). Barrier islands naturally migrate landward as a result of sea level rise. This is accomplished through overwash events where sediments are pushed to the sound side, which contributes to building marsh on the sound side.

Utilization of overwash habitat by wildlife, particularly shorebirds, colonial waterbirds and other waterbirds is also similar to that of coastal beaches and dunes (Refer to Section 4.3.3 for a description of beach and dune communities). However, overwash features in the inlet complex can provide shelter from direct wave and wind energy and therefore, provide more suitable habitat for the birds.

Shorebirds and waterbirds forage and nest on the beach and overwash areas. Overwash events usually occur during storm events or in low areas during spring high tide conditions when seawater flows through the primary dune line, spreading out sand from the beach and dunes. Recently created overwash fans are generally unvegetated and function similar to the dry beach community.

Benefits of Inlet Dune, Beach and Overwash Habitats to Shorebirds, Colonial Waterbirds, and other Waterbirds

Overwash features are not unique to inlets; however the dynamic and productive microhabitats formed as a result of inlet migration are very important to both breeding and non-breeding waterbirds. Overwash habitats include ephemeral pools and bayside mudflats which are important feeding areas to piping plovers at the start of the nesting season and throughout the year (Fraser, 2005; USFWS, 1996). Willets, American oystercatchers, piping plovers, Wilson's

plovers, terns, black skimmers, and killdeers usually nest on open areas such as above the high tide line on coastal beaches, on sand flats at the ends of sand spits, and along blowout areas behind dunes and in overwash areas. These open habitats are utilized by breeding and nonbreeding colonial waterbirds and shorebirds, including the piping plover.

4.3.2.3 INTERTIDAL FLATS AND SHOALS

The intertidal flats and shoals of North Carolina are habitat to a variety of migratory shorebirds, colonial waterbirds, marine mammals, reptiles, fish and macro-infauna. For this reason, these habitats are considered to be a valuable natural resource. The intertidal flats and shoals located within the inlet complex account for approximately 130 acres and are primarily composed of sand and gravel sized particles. These habitats have developed in a dynamic inlet system and, therefore tend to be ephemeral in nature, especially with regard to dynamic island formation within the Inlet. In addition to these ephemeral features, washover areas are also present over many of the flats and shoals. The sandflats, mudflats, and flattened dunes created by washover events are essential for several species of wildlife that utilize North Carolina's coastal resources. In particular, the Wilson's plover and the federally threatened piping plover are both dependent on hurricanes and storms to provide the washovers needed for nesting habitat (Street *et al*., 2005). As mentioned these overwash areas are also important feeding areas to piping plovers at the start of the nesting season and throughout the year (Fraser, 2005; USFWS, 1996).

Benefits of Intertidal Flats and Shoals to Shorebirds, Colonial Birds and Other Waterbirds

During all months of the year, New River Inlet provides important foraging, roosting and nesting habitats. The intertidal shoals and sand flats provide sheltered and isolated habitat for roosting, as well as foraging. Prey resources for shorebirds include mainly invertebrates and small fish. Most shorebirds are aquatic and terrestrial probers/gleaners that can wade in the surf of intertidal areas. Therefore, New River Inlet's habitats and the shorebirds that utilize them are a very important natural resource to the coast of North Carolina. The decrease in suitable habitat world-wide compounded by the increased threats from various sources, enforce the claim by the environmental resource agencies that the remaining habitat available to shorebirds for wintering, migrating, and breeding are becoming more critical.

Black skimmers arrive in North Carolina in May with nesting activities extending from May through August. Black skimmers prefer open, bare sand habitat for nesting with the majority of black skimmer nests and colonies found on natural beaches and dredged spoil islands.

Nesting usually occurs in mixed-species colonies with common, least, and gull-billed terns. Gull-billed terns nest on barrier beaches, natural islands or shoals, and dredged-material islands. Colony substrate is usually sand or a mixture of sand and shell. Colony sites are usually devoid of vegetation or are very sparsely covered with low herbaceous plants. Gull-billed terns arrive in North Carolina between mid-April and early May and create nests that are shallow scrapes usually lined with broken shell fragments or sometimes plant material. North Carolina colony sites may be occupied from April to August (Audubon Society, 2007a).

Common terns nest on "barrier island beaches, natural islands and shoals, marsh islands, and dredged-material islands" (Parnell *et al.*, 1994). Nesting at colony sites begins in late April and early May in North Carolina (Parnell *et al*., 1994).

Least terns nest on barrier beaches, natural islands, or dredged-material islands with a substrate of mixed sand and shell hash and little or no vegetation. Least terns arrive in North Carolina in April, with nesting and egg-laying occurring from early May through early July (Parnell *et al*., 1994).

High concentrations of common loons (*Gavia immer*), red-throated loons (*Gavia stellata*) and northern gannets (*Morus bassanus*) have been observed wintering off North Topsail and Onslow Beach. Onslow Bay is listed as an Important Bird Area by the National Audubon Society partially due to the fact that it supports the largest wintering concentrations of common loons in the State (S. Everhart, pers. comm.). The pre-construction shorebird monitoring survey conducted by North Topsail Beach observed approximately 42 common loons over the period between November 2007 and May 2009. As mentioned in previous sections, various other species of shorebirds, colonial waterbirds and other waterbirds utilize the Permit Area and its microhabitats for a variety of behaviors including, foraging, roosting and nesting.

As mentioned above, shorebirds, colonial waterbirds and other waterbirds will utilize intertidal flats and shoals in the inlet complex for foraging while traveling to their wintering and nesting grounds. Breeding and non-breeding federally endangered species and species of special concern also utilize intertidal shoals. Refer to Section 4.2.4 for these species.

Benthic Macroinfaunal Community

Softbottom habitats are comprised of unconsolidated sediment and defined as "unvegetated", lacking visible structural habitat. However, this "soft" substrate supports an abundance of macroalgae and numerous burrowing organisms (macroinfauna) living below the surface (Street *et al*., 2005). The intertidal flats and shoals in the inlet complex provide habitat for the macroinfaunal community.

Macroinfaunal species are resident to the upper one m (3.28 ft) of the seabed due to the available oxygen content and aeration properties; although some larger species may live deeper in the seabed (USFWS, 2002). Dominant macroinfaunal species typical of the bays and sounds of North Carolina include bivalves, decapods, polychaetes, and amphipods.

Macroinfaunal data, collected as a component of the Bogue Inlet Channel Erosion Response Project, North Carolina, is shown in Table 21. Table 21 illustrates both species composition and species density found during four 2006 post-construction benthic sampling events for the Bogue Inlet Channel Relocation Project (Hague and Carter, 2007). It was evident during the study that Bogue Inlet is a dynamic system in a constant state of change and natural physical disturbance occurs on many spatial and temporal scales. Changes in species composition, diversity, abundance, and richness were analyzed and correlated as an indication of disturbance levels at the three habitat types. Post-disturbance recovery of the benthic communities at each habitat type was also assessed utilizing the successional colonization paradigm.

Baseline (pre-construction) monitoring occurred during 2003, while post-construction monitoring repeated seasonal sampling events in 2007 and 2008. In summary, as of the final 3-year post-construction monitoring event, both the intertidal and marsh habitats were not considered impacted as a result of the Bogue Channel Erosion Response Project. Sampling adjacent to the main ebb channel was initiated to provide evidence of change to the relic shoal habitat as a result of project activities. Results show that natural disturbances in the area, including Hurricane Ophelia, may have equaled project-related effects and that as of the final 2008 sampling assessment, the effects of disturbance in the project area have abated and Stage I of the successional paradigm is evident. This inlet environment remains dominated by physical stress, natural within a high energy inlet.

Macroinfaunal species are a primary food source for several migratory and resident shorebirds, waterbirds, as well as for many commercially and recreationally important fish. Bird species can be found utilizing the Inlet and surrounding estuarine environments as a stop-over feeding station while traveling to their wintering and nesting grounds. Migratory fish species utilizing the inlet depend upon the macroinfaunal community as a food reserve, en route to upstream seagrass beds and estuarine habitats.

Macroinfaunal species are sensitive to physical and chemical changes in water quality and, therefore, are useful indicators of a wide range of natural and anthropogenic stresses. Macroinfauna indicative of a healthy benthic community depend upon variable particle sizes and available interstitial pore space in the substrate. Macroinfauna can therefore be useful for biomonitoring of aquatic habitats because of their limited mobility. This makes them a good indicator of

local conditions. Changes in species diversity, abundance and richness can assist in determining disturbances in the benthic environment, as well as natural seasonal changes. Refer to Section 4.3.3.3 for a full description of these benthic communities.

Benefits of Intertidal Flats and Shoals to Fish

The intertidal flats and shoals of North Carolina are habitat to a variety of, anadromous, estuarine, and marine fish species (USFWS, 2002), such as black grouper (*Mycteroperca bonaci*), blueline tilefish (*Caulolatilus chrysops*), cobia (*Rachycentron canadum*), lane snapper, mahogany snapper, margate, mutton snapper, ocean triggerfish, queen triggerfish (*Balistes vetula*), red drum, red grouper (*Epinephelus morio*), red porgy, red snapper (*Lutjanus campechanus*), schoolmaster, spadefish, banded rudderfish (*Seriola zonata*), black snapper, bluestriped grunt, cero (*Scomberomorus maculates*), dog snapper (*Lutjanus jocu*), gag, goldface tilefish (*Caulolatilus chrysops*), goliath grouper (*Epinephelus itajara*), gray triggerfish, king mackerel (*Scomberomorous cavalla*), white shrimp (*Penaeus setiferus*), brown shrimp (*Penaeus aztecus*), pink shrimp (*Penaeus duorarum*), Atlantic sharpnose shark (*Rhizoprionodon terraenovae*), southern flounder, summer flounder, and tomtate (*Haemulon aurolineatum*). Refer to Table 18 — Essential Fish Habitat Species.

4.3.3 COASTAL BEACH AND DUNE HABITATS

This section identifies the communities in the Permit Area located between mean low water (MLW) and the primary dune.

4.3.3.1 DUNE COMMUNITIES

The CAMA handbook (last updated November 2002) defines the primary dune as "the first mound of sand (measured from the ocean) that is six ft taller than the mean flood level for the area". Frontal dunes are defined by CAMA as "the first mounds of sand that have enough vegetation, height and continuity to offer protection" (NCDCM, 2006a). Dunes and their associated plant species are important in providing shorefront protection against coastal storms and supplying sand to the beach system during periods of erosion.

Vegetation

High temperatures, strong winds, and varying wet and dry conditions, typical of a dune environment, provide unique conditions for plant species with specific adaptations. These specific adaptations include plant species that grow extensive root systems, allowing for prolific growth in unconsolidated beach sand. Perennial grasses are the primary stabilizers of frontal dune systems

along the beach and dune communities along the oceanfront shorelines of Onslow Bay and the inlet shorelines of New River Inlet.

North Carolina is located in a vegetation transition zone, between American beach grass (*Ammophila breviligulata*) to the north, and sea oats (*Uniola paniculata*) to the south. These grasses inhabit the front of most dune systems along the Atlantic Ocean.

Many of the dune communities along the oceanfront shoreline of North Topsail Beach are maintained by dune erosion prevention methods. These preventative measures include the installation of sand fences, which slows aeolian processes and encourages sand deposition (sand trap). Once the initial sand trap has been established, plantings occur at close and wide spacing along several rows to allow sand to penetrate to the center of the planting (Broome, 2007). Since 2000, 75,000 linear ft of sand fence has been installed along North Topsail Beach during dune restoration projects. Approximately 610,000 plants consisting of a variety of American beachgrass, sea oats, bitter panicum (*Panicum amarum*) and saltmeadow cordgrass (*Spartina alterniflora*) have been planted by the Town of North Topsail Beach (Mercer, 2007, pers. comm.).

4.3.3.2 DRY BEACH COMMUNITIES

Eroded material from the dune system contributes to the dry beach located between the toe of dune or scarp and the mean high water line. The dry beach area is susceptible to wind and storm surge, which does not support much vegetation. However, this habitat type provides recreational areas for man and nesting grounds for sea turtles and certain species of shorebirds and colonial waterbirds. Overwash habitats provide similar open space, dry beach communities. Refer to Section 4.3.2.2 for a full description of overwash habitats.

Benefits of Dry Beach Habitats to Sea Turtles

Five species of sea turtles nest on North Carolina beaches: the green sea turtle, loggerhead sea turtle, leatherback sea turtle, hawksbill sea turtle and Kemp's ridley sea turtle. Sea turtles prefer to nest on wide sloping beaches or near the base of the dunes. Dry beaches must allow for the following in order for nesting to be successful: supratidal beach must be wide enough to allow nesting to occur; access to the dry beach must be devoid of obstructions (i.e. fencing, seawalls); the sand compaction must allow for digging, and; the nesting area to be located away from areas of inundation throughout the nesting season. The composition, color, and grain size can affect the incubation time, sex, and hatching success of turtle hatchlings (Street *et al*., 2005). Since overwash features provide similar functional values as dry beach communities, they are also important to nesting sea turtles. Refer to Section 4.2.3 for a description of each of these sea turtle species.

Benefits of Dry Beach Habitats to Shorebirds, Colonial Waterbirds, and other Waterbirds

Beach-nesting birds that utilize dry beach habitats for nesting include terns, black skimmers, Wilson's plovers, piping plovers and American oystercatchers. Refer to Section 4.2.4 for a description of each of these bird species. Terns and black skimmers nest on bare sand and shell with little or no vegetation. These species will change nesting areas in response to changing environmental conditions, such as increased vegetation. This is one reason why it is important that these birds have a number of suitable nesting, foraging, and roosting sites along the coast. Waterbirds use group dynamics to select suitable nesting areas. This grouping creates nesting, resting, and foraging areas with large colonies that can include multiple species of waterbirds (S. Cameron, pers. comm.).

Other colonial waterbirds utilize estuarine habitats, oceanfront shorelines, open dunes, inland areas, and dry beach habitats for foraging, roosting, and nesting. Colonial waterbirds can rapidly populate and alter ranges in response to changes in environmental conditions. Refer to Section 4.3.2 for additional waterbird species found in this habitat.

4.3.3.3 WET BEACH COMMUNITIES

The marine intertidal zone of oceanfront barrier island beaches, or wet beaches, is the area periodically exposed and submerged by waves, varying with frequency and with lunar tidal cycles. This high energy area is habitat to many benthic organisms and foraging grounds for birds and finfish.

Benthic Infaunal Community

On oceanfront beaches, most benthic organisms in the intertidal zone consist of infaunal burrowing forms, particularly polychaete worms (Phylum ANNELIDA), coquina clams (*Donax variabilis*) and mole crabs (*Emerita talpoida*) (USFWS, 2002). Many benthic organisms are filter feeders, which pump large amounts of water through their bodies. As they pump water, they remove sediments and organic matter, thus filtering the water. Some of the organic matter filtered from the water is not used and instead deposited in the sediment. These nutrients can later be recycled by benthic organisms and dispersed back into the water column, making them available to other organisms. Thus, benthic organisms are critical in maintaining the high primary production rates of estuaries. Many benthic macroinfauna are sensitive to changes in water quality and, therefore, are also useful as indicators of a wide range of natural and anthropogenic disturbances.

Research studies conducted along the eastern Atlantic shoreline have focused on the recovery rate of macroinfaunal communities from beach nourishment activities (National Research Council, 1995). The dominant benthic invertebrates researched in relation to beach nourishment activities include mole crabs (*Emerita talpoida*), coquina clams (*Donax variabilis, D. parvula*), some amphipods (almost all Haustoriids), and polychaetes (mostly *Scolelepis squamata*), all of which can be found in North Carolina's intertidal beaches (Street *et al.*, 2005; Peterson *et al*., 2006). While several species of amphipods and polychaetes populate the intertidal and shallow subtidal beaches of North Carolina, their contribution to the total biomass of benthic infauna is low due to their small body size. Therefore, mole crabs and coquina clams dominate the benthic infaunal community due to their biomass (Peterson *et al.*, 2000).

Mole Crab

Emerita talpoida is a very mobile species and is highly adaptable to the harsh and dynamic swash zone environment. Mole crabs have the color of rippled sand at the water's edge and live mostly buried in the sand, with their antennae reaching into the water forming a "V" shaped obstacle in the water as the wave recedes. These antennae filter plankton and organic debris from the water. Mole crabs also eat the tentacles of Portuguese man o' war (*Physalia physalis*), which are collected by winding the tentacle around the mole crab's leg. Camouflage protects the mole crab from predators, primarily fish and birds. Recruitment can occur year round, but large numbers of recruits are found in early summer and in early fall. Diaz (1980) found that most recruitment occurred in September as a result of summer spawning. Amend and Shanks (1999) also found that the reproductive season ended in late September.

Female mole crabs do not rely on tidal cues to time larval release; instead, larvae are released at sunset regardless of the time of the tide. Since larval release occurs within the intertidal zone, the physical wave motions and currents are most likely strong enough to transport larvae away from the shoreline to coastal areas for development (Ziegler and Forward, 2005). Amend and Shanks (1999) reported that larval release is also influenced by wave height during rough seas where larvae are rapidly transported offshore away from adult habitat and predation.

As the swash zone changes with the tide, so does the location of the mole crabs. The mole crabs move up and down the beach with the tides. In the winter, storms carry them offshore possibly into sandbars; however, when the sand is transported back onshore in the spring, the mole crabs travel with it. Bowman and Dolan (1985) found that the overwintering populations migrate onshore in April during a period of rapidly increasing water temperatures. These population fluctuations are an important consideration when using *E. talpoida* as an indicator species for assessing environmental impacts.

As stated by Peterson *et al.* (2006) and the National Research Council (NRC, 1995) intertidal beaches are dynamic and experience frequent sediment erosion, transportation and deposition during, and due to, winter storms. *Emerita talpoida* is well adapted to this constantly changing, and stressful, environment and natural disturbances. Peterson *et al.* (2006) and Rakocinski *et al.* (1996) found that the mole crab exhibited a pattern of initial depression after sedimentation but fully recovered in less than one year after beach nourishment.

Coquina Clam

Coquina clams (*Donax variabilis)* are small, generally less than 2.5 cm in length, and possess wedge-shaped shells (Ruppert and Fox, 1988). Like most bivalves, coquinas are filter feeders, ingesting phytoplankton, bacteria, and other small suspended particles in the surf zone. The wet beach environment is extremely dynamic, eroding and accreting several times in a period of months. Although many organisms feed in the surf zone, this clam has unique adaptations to this habitat type, making the coquina clam a key habitat indicator species.

Donax variabilis migrates shoreward with the incoming tide and seaward with the outgoing tide (Ellers, 1995). While these clams spend most of their time buried in the sand, they emerge several times per tidal cycle to ride waves. Ellers (1995) named this method of movement "swash-riding" where each clam emerges from the sand and the flow from waves drags it to a new position to maintain optimum position at the sea's edge. Coquina clams actively migrate up and down the beach during spring and summer; however these tide-related migrations cease in winter as *D. variabilis* eventually moves into the subtidal zone in late fall. The fluctuation of the location of populations in relation to the changing tides is an important consideration when assessing this species and one should expect variation if sampling at different tidal levels.

Both males and females are required for reproduction. Spawning occurs subtidally in winter and juveniles recolonize the intertidal beach in late winter (Ruppert and Fox, 1988). The typical lifespan of coquina clams is two years.

As stated by Peterson *et al.* (2006) and the National Research Council (NRC, 1995) intertidal beaches are dynamic and experience frequent sediment erosion, transportation and deposition during, and due to, winter storms. Like *Emerita talpoida, Donax* species are well adapted to this constantly changing, and stressful, environment and natural disturbances. While Peterson *et al.* (2006) found that the mole crab exhibited a pattern of initial depression after sedimentation but fully recovered in less than one year after beach nourishment, *Donax* and amphipods failed to even initiate recovery in the year following the Bogue Banks beach nourishment project.

Benefits of Wet Beach Habitats to Fish

Many infaunal species are important food sources for demersal predatory fishes and mobile crustaceans. Some of the species that forage on benthic invertebrates in the surf zone and shoals include inshore lizardfish (*Synodus foetens*), pompano (*Alectis crinitus*), pigfish, pinfish, spot, kingfish (*Menticirrhus littoralis, M. americanus*), red drum, Atlantic croaker, northern sea robin (*Prionotus carolinus*), and summer flounder, weakfish (*Cynoscion regalis*) and penaeid shrimp (Street *et al*., 2005). Many of these species use the high energy environment as protection from prey species, as well as for feeding grounds. Refer to Section 4.3.2.3 for additional information on fish utilization of the intertidal zones of the Permit Area.

Benefits of Wet Beach Habitats to Shorebirds, Colonial Waterbirds, and Other Waterbirds

Many infaunal species are important food sources for a variety of bird species, especially the beach-nesting birds mentioned in Section 4.3.3.2. Other colonial waterbirds that utilize estuarine habitats, oceanfront shoreline, open dunes, and inland areas also utilize wet beach habitats for foraging, roosting, and nesting. Colonial waterbirds can rapidly populate and alter ranges in response to changes in environmental conditions. Refer to Section 4.3.2 for additional waterbird species found in this habitat.

4.3.4 MARINE HABITATS

Cowardin (1979) classifies marine habitats as open ocean waters overlying the continental shelf and its associated high energy coastline where salinities exceed 30 ppt. Marine nearshore softbottom communities are found in the intertidal zone as well as the subtidal zone. Marine intertidal and subtidal zones along the shoreline are highly affected by tides and bottom friction. North Carolina's tidal amplitude along ocean shoreline is greatest where the continental shelf is widest in the southern coastal area; average tidal height is approximately 2 ft (0.6 m) near Cape Hatteras and 4.3 ft (1.3 m) near Cape Fear (Street *et al*., 2005). Marine hardbottom communities are located in both nearshore and offshore waters of North Topsail Beach. CPE baseline investigations confirmed the presence of hardbottom resources located in the nearshore (approximately 350 ms from the February-March 2002 mean high water line [-17 to -23 NAVD]) and offshore (122 to 305 ms from the February-March 2002 mean high water line [-43 NAVD]) of North Topsail Beach.

4.3.4.1 SOFTBOTTOM COMMUNITIES

Soft bottom habitat is the unvegetated bottom sediment in all coastal systems, and includes features such as inlets, shoals, channel bottoms, intertidal ocean beaches, and cape shoals. Soft bottom plays a key role in primary productivity in shallow estuarine and marine systems. This habitat strongly influences the water column through dynamic cycling processes, storing and releasing nutrients and chemicals over time. Other ecosystem functions of soft bottom include the reduction of physically destructive storm effects on oceanfront beaches, and providing sand sources for barrier island and inlet migration.

This "soft" substrate supports an abundance of macroalgae and numerous burrowing organisms (macroinfauna) living below the surface (Street *et al*., 2005). Intertidal shoal, marine intertidal (wet beach) and subtidal areas in the Permit Area provide a total of 2,497 acres of possible habitat for softbottom communities. The offshore borrow area contains approximately 482 acres of softbottom habitat. Remote and diver verified investigations have identified sand and muddy bottom habitat types in the nearshore waters 20 to 46 ft (6 to 14 m) of North Topsail Beach (CPE, 2006). Refer to Figures 8a through 8c for location and specific acreage for each of these habitat types.

Mudflats are sedimentary intertidal habitats created by deposition in low energy coastal environments, particularly estuaries and other sheltered areas. The sediments generally consist of silts and clays with a high organic content" (NMFS, 2006 - Mudflats). Sand bottoms consist of materials with grain sizes more coarse than silt (>0.0625 mm) (Anderson, 2006). Mud and sand bottoms can be found throughout New River and nearshore areas of North Topsail Beach. Penaeid shrimp, blue crab, red drum and flounders utilize this habitat type as nursery, foraging and refuge areas.

Soft bottom habitat is particularly important as a foraging area for all size ranges of bottom feeding fish and invertebrates, such as blue crabs, shrimp, flounders, striped mullet, spot, croaker, and kingfish. Burrowing mollusks (e.g., hard clams, coquina clams), flatfishes (e.g., southern flounder, hogchoker) and baitfish (e.g., striped mullet) are highly associated with shallow soft bottom, while larger benthic feeding predators (e.g., weakfish, coastal sharks, sturgeons) typically utilize deeper soft bottom areas. Valued fishery species that depend on healthy soft bottom habitat include hard clams, shrimp, blue crabs, southern flounder, Atlantic croaker, striped mullet, kingfish, and spot. Of these, the NCDMF stock status of Atlantic and shortnose sturgeons, southern flounder, and coastal sharks was overfished. Striped mullet and Atlantic croaker were listed as Concern. The Atlantic sturgeon, which is classified as Overfished, has been under a fishing moratorium since 1991 but has not shown signs of recovery. Coastal inlets have been federally designated as Habitat Areas of Particular Concern for blue crab, estuarine-dependent snapper and grouper, penaeid shrimp, and red drum.

Inadequate data are available to clearly indicate the current condition of soft bottom habitat. Fortunately this habitat is relatively resistant to a changing environment. This is the most abundant submerged coastal fish habitat, and estuarine acreage of soft bottom has undoubtedly increased over time as shell bottom, SAV, and wetland habitats have declined. Threats of greatest concern include large-scale alterations such as dredging of productive shallow bottom areas, construction of marinas and docks, bottom dredge and trawl fisheries in estuarine waters, and large-scale beach nourishment. Depletion of oxygen and toxic contamination of bottom sediments are the major water quality concerns since those conditions can cause mortality or poor recruitment of benthic invertebrates, which in turn can affect food availability for numerous benthic feeding invertebrates and fish. Therefore, minimizing dredging of productive shallow bottom, properly managing beach nourishment to maintain healthy benthic communities in the surf zone, and reductions in nutrient and toxin loading in all coastal waters are the primary management needs for soft bottom.

Benthic Infaunal Community

Softbottom, nearshore intertidal (as discussed in Section 4.3.3.3) and subtidal areas, as well as offshore softbottom areas, serve as important habitats for benthic organisms that live on or within the sediment. Since North Carolina is located at a transition between two major physiographic and zoogeographic zones, the marine subtidal bottom supports a high diversity of invertebrates.

New River Inlet nearshore softbottom communities are dominated by annelids, mollusks, and crustaceans. These organisms provide food for wading birds, shorebirds, fish and other animals. Nearshore softbottom habitats also serve as passages for migratory fish that travel into and out of the sounds. Refer to Section 4.3.3.3 for a description of the dominant infaunal species found in softbottom communities.

Offshore softbottom communities along the North Carolina coast are relatively diverse habitats containing over a hundred polychaete taxa. Tube dwellers and permanent burrow dwellers are important benthic prey for fish and epibenthic invertebrates. These species are also most susceptible to sediment deposition, turbidity, erosion, or changes in sediment structure associated with sand mining activities, compared to other more mobile polychaetes.

Periodic storms can affect benthic communities along the Atlantic coast to depths of approximately 35 m (115 ft). As a result, softbottom communities tend to be dominated by opportunistic taxa which have adapted to relatively quick recovery from disturbance (Street *et al.*, 2005). Seasonal climatic changes can also influence the diversity and abundance of macroinfaunal species in these areas. Species abundance during the late winter and early spring is typically higher with densities of over 3,500 per 100cm^2 commonly observed (Mallin *et al*., 2000),

although individual species vary considerably in their abundance throughout the year.

Benefits of Soft Bottom Communities to Fish

Softbottom habitat is used to some extent by almost all native coastal fish species in North Carolina. However, certain species are better adapted to, characteristic of, or dependent upon shallow unvegetated bottom. Flatfish, rays and skates are well suited for utilization of softbottom. Juvenile and adult fish species that forage on the rich abundance of macroalgae, detritus and small invertebrates are highly dependent on the condition of softbottom. Species common to shallow sand and mud bottom environments include Atlantic spadefish, black grouper, blueline tilefish, cobia, goldface tilefish, gray snapper, gray triggerfish, hogfish (*Lachnolaimus maximus*), jolthead porgy, lane snapper, mahogany snapper, margate, mutton snapper, ocean triggerfish, white shrimp, brown shrimp, pink shrimp, queen triggerfish, red drum, red grouper, red porgy, red snapper, rock shrimp (*Sicyonia brevirostris*), saucereye porgy, schoolmaster, scup, southern flounder, spiny lobster, summer flounder, tomtate and white grunt. Refer to Table 18 —Essential Fish Habitat Species.

4.3.4.2 HARDBOTTOM COMMUNITIES

Hardbottom habitats are generally subtidal features that consist of rock or consolidated sediments occurring from the coast to the Continental Shelf (NMFS, 2006). The hardbottom communities identified by the sidescan sonar results and confirmed by CPE marine biologists in June and August 2005, were quantified in the project GIS to determine the total identified nearshore (2,000 ft or less from shore) and offshore (greater than 2,000 ft from shore) hardbottom resources. The nearshore hardbottom community totaled 260,537m^2 and the offshore hardbottom totaled 1,652,857m^2. Refer to Figures 8a through 8c for the location of hardbottom communities in relation to the Permit Area.

NEARSHORE HARDBOTTOM COMMUNITIES

Underwater investigations of the nearshore hardbottom of North Topsail Beach were conducted in 2005 and 2006 by CPE marine biologists. Nearshore hardbottom resources were confirmed along the oceanfront shoreline, approximately 350 ms from the 2002 shoreline (CPE Staff, personal communication). The location of these features corresponds with the hardbottom areas described in the Coastal Habitat Protection Plan (CHPP) (Street *et al*., 2005).

The minimum and maximum relief of the hardbottom was measured along shore-perpendicular transects by CPE marine biologists in 2005. A minimum height of

0 cm and maximum height 35 cm was recorded for the nearshore hardbottom features (Appendix H).

Nearshore hardbottom features are located in a high energy coastal environment, and as such can be ephemeral in nature. The hardbottom communities within the Permit Area undergo large fluctuations in temperature, wave action, storm surge and sedimentation (intermittently exposed as a result of sediment). The species occupying this habitat, therefore, are generally tolerant of elevated turbidity and wave energy, temperature and salinity fluctuations and periodic burial. The species attached to or associated with this natural resource have adapted to the wider range of environmental conditions to which they are exposed. Stresses to this resource must exceed the natural temporal range of conditions to which it has adapted in order to adversely affect this resource in the long-term.

Heavy sediment and particulate loading was observed during diver investigations which prevented CPE marine biologists from completing flora and fauna surveys in the northern fill area during the 2005 investigations (visibility ranged from 0 to $\leq$ 30 cm). *In situ* investigations conducted along the south fill area in August 2006 documented similar poor visibility conditions; however, no additional hardbottoms were found along the nearshore of the south section. Benthic functional groups found in nearshore hardbottom of the central fill area include macroalgae, tunicates, bryozoans, sponges, hydroids, annelids, octocorals and stony corals, primarily the species *Oculina robusta*. Macroalgae, primarily included the phylum Rhodophyta (red algae), including species of *Gracilaria, Gelidium, Cryptonemia*, and *Dasya*. Refer to the CPE Summary of Field Investigations, Hardbottom Investigation Report in Appendix H.

Benefits of Nearshore Hardbottom to Fish

CPE diver observations and laboratory identification determined that sessile turritellid gastropods, bryozoans, calcareous algae, scleractinians and gorgonians dominated the surface of the live rock. The species identified by Crowson (1980) correspond with those species identified during CPE's underwater investigations. Common species include: *Oculina robusta*, *Astrangia poculata* (Scleractinia), *Leptogorgia* spp.(Octocorallia), and *Vermicularia spirata* (Gastropoda). However, the density and diversity of biota on the irregular rock surface was higher than that observed by Crowson (1980) on the platform type rock surface.

Gorgonians (*Leptogorgia* spp.) are important to hardbottom communities due to their structural complexity, i.e., vertical and horizontal branching, which provides habitat for a variety of invertebrates and access to food resources in the water column well above the seafloor (Mitchell *et al*., 1992; DeVictor, 2006). Mitchell *et al*. (1992) documented more than 1,500 organisms representing 135 different

species from three *Leptogorgia virgulata*, three *L. hebes* and three *Titanideum frauenfeldii* colonies observed off Georgia's coast. *Leptogorgia hebes* on the east coast of Florida typically occurs outside inlets and on nearshore reefs (SMS, 2006), suggesting that it has a greater tolerance of the two species to fluctuations in turbidity, sedimentation, temperature and salinity. It may be found where others octocorals are unable to colonize.

Fish are an important component of the overall trophic structure found in marine environments (Street *et al.*, 2005). Hardbottom provides habitat for an abundance of reef organisms and fish. Nearshore hardbottom provides an important settlement and nursery habitat for immigrating larvae of many important fisheries species (Refer to Table 18). An irregular surface allows larvae to settle into the interstitial spaces, voids and overhangs, while providing protection from the scouring action of waves and predators. Hardbottom provides not only refuge and foraging areas, but also spawning areas. Species known to spawn on nearshore hardbottom include black sea bass (*Centropristis striata*), sand perch (*Diplectrum formosum*), sheepshead (*Archosargus probatocephalus*), Atlantic spadefish (*Chaetodipterus faber*), seaweed blenny (*Parablennius marmoreus*), inshore lizardfish (*Synodus foetens*), and gobies (*Loglossus calliurus* and others) (Street *et al.*, 2005).

Benefits of Nearshore Hardbottom to Birds

Pelagic birds possibly found as they pass from rookeries to offshore feeding grounds along the North Carolina coast include petrels (*Pterodroma* spp.), shearwaters (*Calonectris diomedea*, *Puffinus* spp.), and northern gannets (*Morus bassanus*). Data concerning pelagic birds in the vicinity of the Permit Area has yet to be confirmed; however Cameron (2007) sighted northern gannets utilizing nearshore and offshore waters for food resources. Gannets dive up to 50 ft underwater to access food resources (i.e. fish and squid) in the water column.

Benefits of Nearshore Hardbottom to Sea Turtles

The nearshore shallow waters of North Carolina provide breeding, feeding and developmental areas for five species of sea turtles: loggerhead, green, hawksbill, Kemp's ridley, and leatherback (Epperly *et. al*., 1990).

After leaving the nesting beach, hatchling green and loggerhead turtles head towards the open ocean pelagic habitats (Carr, 1987) where their diet is mostly omnivorous with a strong carnivorous tendency in green turtles (Bjorndal, 1985). At about 20-25 cm carapace length Atlantic green turtles enter benthic foraging areas and shift to an herbivorous diet, feeding predominantly on sea grasses and algae but may also feed over coral reefs and rocky bottoms (Mortimer, 1982). At about 40 to 50 cm carapace length, loggerheads move into shallow water where they forage over benthic hard and soft bottom habitats (Carr, 1986). Loggerhead sea turtles feed on benthic invertebrates including mollusks, crustaceans, and

sponges (Mortimer, 1982) but have also been found to eat fish, clams, oysters, sponges, jellyfish, shrimp, and crabs when nearshore. Hawksbill and Kemp's ridley sea turtles are carnivorous (Mortimer, 1995) with a principal food source of crustaceans, mollusks, other invertebrates, and fish (Schwartz, 1977). Hawksbills feed on encrusting organisms such as sponges, tunicates, bryozoans, mollusks, and algae; whereas Kemp's ridleys feed predominantly on portunid crabs (Bjomdal, 1985). Leatherback sea turtles are carnivorous (Mortimer, 1995) and feed primarily on cnidarians and tunicates (salps, pyrosomas) throughout the water column but are commonly observed feeding at the surface (Bjorndal, 1985).

OFFSHORE HARDBOTTOM COMMUNITIES

Typically, offshore hardbottom features are generally more persistent and less ephemeral in nature than nearshore hardbottom features. This resource's depth and distance from the shoreline provides a buffer for the short-term environmental fluctuations experienced in the nearshore. However, this resource is generally not as resistant to excesses of turbidity and sedimentation. Sediment migration observed by CPE marine biologists along the offshore hardbottom transects (TS 11 and 12) in August 2006 indicated approximately 0.6 m (2 ft) of sedimentation had occurred since October 2005. This natural migration of sediment indicates that the offshore hardbottom undergoes periodic covering and uncovering and therefore supports flora and fauna potentially adapted to these occurrences.

Sidescan sonar and diver-verified ground-truth investigations determined approximately 408 acres of offshore hardbottoms in the vicinity of North Topsail Beach. Dominant benthic functional groups observed at the offshore hardbottom sites include macroalgae, octocorals, encrusting red algae, sessile worms and stony corals. Again *O. robusta* is the dominant stony coral in this environment, and *Leptogorgia virgulata*, *L. hebes*, and *Titanideum frauenfeldii* are the dominant octocorals. As seen in the nearshore hardbottom, vegetative communities documented by CPE marine biologists on offshore hardbottom consist of macroalgae of the phylum Rhodophyta, including primarily species of *Gracillaria* and *Cryptonemia*. Refer to the CPE Summary of Field Investigations Report in Appendix H.

Benefits of Offshore Hardbottom to Birds

Refer to Nearshore Hardbottom Benefits to Birds for details on the species of birds found utilizing the resources of hardbottom habitats.

Benefits of Offshore Hardbottom to Fish

While hardbottom resources to fish are discussed under Nearshore Hardbottom Benefits to Fish, this section reviews several state listed, managed fish species found within the vicinity of New River Inlet. Table 18 lists species identified by both CPE and the NMFS, and includes the affiliated management council and/or commission (i.e. Atlantic States Management Fisheries Council, South Atlantic Fisheries Management Council, Mid Atlantic Fisheries Management Council), NCDMF Stock Status, expected life stage in the New River Inlet area, fish habitat associated with the species, and associated habitat that may be found in the New River Inlet area.

Approximately 89 fish species may occur in the offshore coastal waters (including nearshore, surf zone and beach habitat), intertidal and shallow water environments, subtidal habitats (i.e., New River), shellfish and seagrass habitats, bays and lagoon environments (including Stump Sound), inshore sandy and/or muddy bottom habitats, and estuarine and salt marsh environments (NCDMF, 2003b). Commercial fishing contributes to the economy of North Carolina and, as such, is an important economical resource to the State as well as its local residents, who also depend on finfish as an important food source. Fish are also an important part of the diet of many other animals such as shore and water birds, turtles, and whales. In addition to a food resource, finfish also contribute to the recreational sport of fishing.

Hickory shad (*Alosa mediocris*) – Hickory shad are listed by the NCDMF with an unknown stock status. *A. mediocris* are anadromous fish that spend most of their life in oceanic waters, but return to fresh waters in the spring to spawn (NCDMF, 2003b).

Striped bass (*Morone saxatilis*) – Striped bass are listed as overfished by the NC Division of Marine Fisheries (NCDMF) in the central and southern regions of North Carolina. A revised Fisheries Management Plan (N.C. Estuarine Striped Bass Management Plan) is currently being developed for the *M. saxatilis* by the NCDMF. Striped bass are anadromous fish that spend a majority of their lifetime in estuarine waters, but migrate to freshwaters in the spring to spawn (NCDMF, 2003b).

Kingfish – Three species of Kingfish or sea mullet are found in North Carolina: southern kingfish (*Menticirrhus americanus*), northern kingfish (*Menticirrhus saxatilis*), and gulf kingfish (*Menticirrhus littoralis*) are listed with an unknown stock status by the NCDMF. The southern kingfish is listed as the most abundant of the three species. However all three species have short life spans. Kingfish are affected by seasonal fluctuations in water temperatures; where they reside in estuarine and nearshore waters in the warmer months, moving to offshore deeper waters in the colder months (NCDMF, 2003b).

Southern flounder (*Paralichthys lethostigma*) – Southern flounder are a species of concern to the State of North Carolina, and, according to the 2004 stock assessment, are overfished. A Fishery Management Plan for the southern flounder was developed by the NCDMF in 2005. The southern flounder can be found over sand bottoms, mud bottoms in estuaries, and coastal waters to about 40 m (131 ft) in depth. Southern flounder are estuarine dependent flounder found in the same family as the summer flounder (NCDMF, 2003b).

Southern flounder can tolerate wide variations in environmental conditions, such as salinity levels. Southern flounder are frequently found in brackish bays and estuaries, marine waters, and occasionally freshwater. This species of flounder moves to offshore, deeper waters in the winter and early spring, and inshore and north during late spring, summer, and fall. Spawning for the southern flounder is close to shore, over the continental shelf, from November through March. Unlike summer flounder, many adult southern flounder return to the estuaries of North Carolina after spawning (NCDMF, 2003b).

Striped mullet (*Mugil cephalus*) – Striped mullet are listed as currently viable and have not been listed as overfished since 1998. The N.C. Marine Fisheries Commission adopted the State Fisheries Management Plan on April 27, 2006. Spawning migration of the fish occurs during the fall season when the fish move from freshwater and/or estuarine environment to marine waters. Striped mullet have also been identified as a critical link between the lower and upper food chain, by feeding on microorganisms and microalgae; while in turn fed on by birds, other fish, sharks, and porpoises (NCDMF, 2003b).

The following section describes fish species managed by the NCDMF protected under the authority of the Atlantic States Marine Fisheries Commission (ASMFC).

American shad (*Alosa sapidissima*) – American shad are listed as a species of concern by the NCDMF based on the fish's importance to commercial and recreational fisheries along the Atlantic coast. Commercial landings decreased in 2005, falling below the 10-year average. Since 1985, the American shad has been managed under the authority of the ASMFC. American shad are highly migratory, anadromous fish that spend the majority of their life in marine waters and return to fresh water to spawn. Juveniles utilize estuarine waters as nursery areas for their first growing season until a decrease in water temperatures triggers an emigration to the ocean. Juveniles remain in ocean waters until maturity then return to fresh water to spawn once they reach sexual maturity. Juveniles may also be found in brackish waters. Most shad returning to North Carolina waters are short-lived and usually die shortly after they have spawned (NCDMF, 2003b).

Atlantic croaker (*Micropogonias undulates*) – Atlantic croaker are managed solely by the ASMFC and are listed as viable and are not currently overfished. Croaker inhabit mainly mud and sand bottom areas, feeding on crustaceans, worms, mollusks, detritus, and small fishes. Mud and sand bottom habitats in estuaries are considered nursery and feeding grounds for the croaker. Atlantic croakers are the most abundant inshore bottom dwelling fish from Chesapeake south through the Gulf of Mexico (ASMFC, 2006).

Atlantic menhaden (*Brevoortia tyrannus*) – Atlantic menhaden are managed solely by the ASMFC and are listed as viable under the NCDMF stock status report. Atlantic menhaden are estuarine-dependent fish that serve as prey for many fish, sea birds, and marine mammals. Adults are found in near surface waters, usually in shallow areas overlying the continental shelf, but are in greatest abundance immediately adjacent to major estuaries (Fishbase, 2003). Adults and juveniles migrate in and out of bays and inlets. The menhaden fishery is one of the most important and productive fisheries on the Atlantic coast (ASMFC, 2003).

Atlantic menhaden migrate in the fall and early winter to North Carolina, around Cape Hatteras, to spawn. The majority of spawning occurs primarily offshore 32-48 km (20-30 mi) during the winter. However, migration patterns are related to spawning habits, and some spawning occurs every month of the year. Larvae are carried into inlet and estuarine nursery areas by ocean currents. Menhaden also migrate to the northern parts of their range, outside of the Permit Area, in the spring and others even migrate to Florida waters in the winter.

Atlantic sturgeon (*Acipenser oxyrinchus*) – Atlantic sturgeon are managed by the ASMFC who considers this species as depleted along the Atlantic coast. The NCDMF lists *A. oxyrinchus* as an overfished species. The sturgeon is known to inhabit the northwest and central-west Atlantic Ocean, as well as Labrador, Newfoundland, Canada to northeastern Florida. This fish may be extirpated from the New River area although it can be found in Bogue Sound to the north.

Adult Atlantic sturgeon are typically found along the shallow waters of the continental shelf. This fish is also anadromous and requires the freshwater of an estuarine system to spawn. The timing of spawning is dependant on the water temperature. Spawning usually occurs when the water temperature ranges between 15°C and 23°C (59°F and 73°F) (Caron, 2001). Juveniles will remain in the estuaries and brackish waters until 3-5 years of age or up to 76-91.5 cm (30-36 in) in length (FishBase, 2003).

Spot (*Leiostomus xanthurus*) – Spot are managed under authority of the ASMFC and are currently listed as viable by the NCDMF. Spot are estuarine dependant, but can also be found over sandy bottoms to 60 m (197 ft) along the western Atlantic coastline. Spot spawn in nursery and feeding grounds of estuaries in the

summer and fall. Juvenile spot fish can remain in the estuaries throughout the entire year (FishBase, 2003).

Spotted sea trout (*Cynoscion nebulosus*) – Spotted sea trout utilize Habitat Areas of Particular Concern, and are currently listed as viable by the NCDMF. Its stock status is found to be heavily dependant on environmental conditions. The spotted sea trout can be found along the western Atlantic from New York to south Florida and in the Gulf of Mexico. Spotted sea trout is estuarine dependant, but can also be found in the nearshore waters, subtidal areas, and submerged aquatic vegetation (SAV) near the Permit Area (though no SAV has been confirmed in the Permit Area). Juvenile spotted sea trout are typically found in seagrass beds, while adult species inhabit rivers, salt marshes, and coastal areas.

Tautog (*Tautoga onitis*) – The NCDMF has managed the tautog under the authority of the ASMFC since 1996, who classifies the North Carolina statewide population as overfished. However, since the Fisheries Management Plan does not define a specific biomass target, it cannot be determined if the population is overfished. No estimates of stock size or mortality are available for tautog in North Carolina. Tautog prefer submerged hard-structure habitat, such as offshore and inshore wrecks, artificial reefs, rocky reefs, and pier areas. Juvenile tautogs rely primarily on shallow, estuarine, macroalgal areas and eelgrass beds as nursery habitat. During the spring, when water temperatures are close to 9°C (48ºF), tautog migrate inshore to spawn in estuaries and nearshore marine waters. Tautogs remain inshore throughout the summer and move to offshore wintering areas in the fall when temperatures are below 11°C (52ºF). Some adults will remain offshore throughout the year (NCDMF, 2003b).

Weakfish (*Cynoscion regalis*) – Weakfish are solely managed within the State waters of the Atlantic by the NCDMF under the authority of the ASMFC. The NCDMF currently lists the weakfish as a species of concern. There is currently no accepted peer-reviewed stock assessment for Atlantic coast weakfish and the current stock status is under debate. Commercial and recreational landings along the Atlantic coast have plummeted in recent years and are currently at the lowest level on record. This fish can be found along the intertidal flats, creeks and river systems, shallow sand and mud bottoms, and in the salt marshes within and near the Permit Area. Weakfish utilize the upper reaches of the estuaries (fish nursery areas) to feed and spawn during the summer months. Adult weakfish inhabit the shallow coastal waters of the western Atlantic from Nova Scotia to northern Florida (NCDMF, 2003b).

OFFSHORE TURTLE HABITAT

Surveys and tracking studies show that as fall approaches and the turtles leave inshore waters and bays in North Carolina and Virginia, they migrate close to the coast moving south of the Cape Hatteras area (Keinath *et al*., 1987).

Inland water temperatures in North Carolina often fall below the lethal lower limit of loggerhead sea turtles (5 to 6.5º C [41 to 43.7º F]) (Musick *et al*., 1997) and account for the movement of juveniles from the sounds of North Carolina to coastal waters (Epperly *et al*., 1995). Those juveniles that remain in North Carolina waters winter off the coast near the western edge of the Gulf Stream (Epperly *et al*., 1995).

A total of 12 nesting females have been tracked since 2003. After being tagged, the turtles traveled north and south from North Carolina, utilizing waters in New Jersey and Florida. Three of the satellite tracking units from 2005 are still transmitting. The transmitters have provided some novel and useful information about the migratory and foraging behavior and natural history of the loggerhead sea turtle in this region (http://www.seaturtle.org, 2007).

A recent satellite turtle tracking effort examined the movements of a female loggerhead after her nesting season in 2005 on Bald Head Island, North Carolina. The female loggerhead moved northwards which is typical behavior for the majority of post-nesting loggerhead turtles tracked from nesting beaches in Georgia, South Carolina and North Carolina. The loggerhead then spent the fall months just off the coast of Hatteras Island, in between Cape Hatteras and Oregon Inlet in North Carolina. In December 2005, this female loggerhead then moved southwest, towards Cape Lookout before moving into Onslow Bay where she remained for nearly three months during the winter of 2005/2006. It is rare to find an adult turtle in the inshore waters of North Carolina (Coyne and Godley, 2005).

4.4 WATER COLUMN

The water column habitat as defined in the CHPP is “the water covering a submerged surface and its physical, chemical, and biological characteristics. Water column properties that may affect fisheries resources include temperature, salinity, dissolved oxygen (DO), total suspended solids, nutrients (nitrogen, phosphorus), and chlorophyll *a*. Other factors, such as depth, pH, water velocity and movement, and water clarity, also affect the distribution of aquatic organisms” (Street *et al*., 2005). The water column habitat surrounds and supports all aquatic organisms and connects all coastal fish habitats. Consequently, clean and healthy waters are critical to the overall viability of coastal fish habitats and aquatic organisms. The general distribution of fish within the water column is determined by the physical and chemical properties of each

unique water body (i.e., salinity, temperature), while the abundance, diversity, and health of coastal fish and invertebrates are strongly influenced by water quality conditions (i.e., oxygen, turbidity, nutrients). The water column provides the necessary medium for spawning and transport of eggs and larvae to habitats favorable for survival and growth. In addition, coastal waters are an important source of primary production, providing food for the survival of early life stages of aquatic organisms. Another critical function of the water column is to support other important food sources for pelagic species, such as river herring, bluefish, and Spanish mackerel, and to serve as a critical corridor for migration. Particularly important areas of the water column include inlets, shallow estuarine nursery areas, anadromous fish spawning and nursery areas, and the nearshore surf zone.

4.5 WATER QUALITY

Water quality is important to the health and survival of estuarine flora and fauna. Because all fish habitats are connected through the water column, maintaining and restoring water quality is the basic component of habitat protection and enhancement. Marine animals such as anadromous fish and shellfish require specific ranges of salinities, temperatures, and turbidity levels. Flora, such as seagrass beds, rely on clear waters for photosynthesis and survival. If waters are highly turbid, seagrass cannot obtain adequate sunlight for survival and the loss of seagrass communities can result. However, due to the variation in water quality in an estuarine system, flora and fauna are accustomed to the dynamic system and can adapt to minimal and temporary changes.

The New River lies in the southwestern portion of the White Oak River Basin and is a blackwater river whose watershed is located entirely within Onslow County. The river is a narrow freshwater body until it reaches the City of Jacksonville, near the US 17 bridge where it widens, slows and begins to exhibit estuarine influence until it discharges into the Atlantic Ocean. The river basin above (or north) of the City of Jacksonville is comprised of gum-cypress swamps with upland areas used for agriculture (primarily swine farming) and forestry (NCDWQ, 2001). Land use in the lower portion of the watershed is dominated by the City of Jacksonville and the U.S. Marine Corps' Camp Lejeune, and the Town of Sneads Ferry near the mouth. Extensive brackish and saltwater marshes and maritime hammocks surround the New River Inlet.

The North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Quality provides a Basinwide Assessment Report for all 17 major river basins within North Carolina every five years. The White Oak River Basin (which includes the New River Inlet and surrounding area), was sampled by the Environmental Sciences Section (ESS) in 1994, 1999, and, most recently, in 2004. The ESS collects a variety of biological, chemical and physical data that can be used in several ways for the basinwide planning program. An Ambient Monitoring System study was also conducted for the White Oak River

Basin, which collected data from 1999 through 2004. In addition, a phytoplankton monitoring study was conducted in the New River in 1998 which indicated that overall water quality conditions have improved since 1986, although it is still impacted and some short-term trends indicate that nutrient concentrations have begun to increase at some sites. A previous study conducted from 1986 through 1989 resulted in the New River being classified as Nutrient Sensitive Waters (NSW), since some portions of the river exhibited nutrients, phytoplankton, and chlorophyll *a*. Bioclassifications for New River were listed as 'good' in the 1980's, but declined to a good-fair rating since 1990.

4.5.1 Salinity

A primary factor affecting the distribution of estuarine-dependent fish and shellfish is salinity (FFWCC, 2006). The New River estuary is a small, coastal plain system which includes three major bays and several smaller bays and coves. The salinity structure is primarily determined by seasonal freshwater discharge from the New River. Moderate stratification conditions persist throughout the middle bay portions of the system, but vertical stratification is infrequent in the lower estuary. Tidal influence is generally restricted to the lower estuary wherein it increases vertical mixing and maintains relatively stable salinities. The high salinity time period is September through November; transitional is May through August and December through January; and low is February through April (NOAA, 2003).

The NCDENR reported a range in salinity of 20.1 to 38.6 ppt at the Ambient Monitoring Station: ICW at NC 210 near Goose Bay (1999-2002). This range in salinity levels is tolerated by many species of fish and invertebrates. Anadromous fish such as the shortnose sturgeon (*Acipenser brevirostrum*) can spend all or part of its life in the low salinity levels of the estuarine areas of New River Inlet; however, it can also be found in salinity levels above 30 ppt, including the open ocean (35 ppt) (Gilbert, 1989).

4.5.2 Turbidity

Turbidity, expressed in Nephelometric Turbidity Units (NTU), quantitatively measures the light-scattering properties of water. However, the properties of the material suspended in the water column that create turbid conditions are not reflected when measuring turbidity. The two reported major sources of turbidity in coastal areas are very fine organic particulate matter, and sand-sized sediments that are re-suspended around the seabed by local waves and currents (Dompe and Haynes, 1993).

North Carolina state guidelines limit turbidity in the New River to values under 25 NTU above ambient levels outside turbidity mixing zones (Refer to Section 6.4.5 for Hardbottom Monitoring Plan). CPE marine biologists used a LaMotte 2020 to field test water samples collected one m above the seafloor in August 30, 2006. Sample bottles were rinsed prior to CPE marine biologists collecting samples in

water column, while avoiding impact with seafloor. Turbidity readings in the nearshore of the south fill section (approximately 1,500 ft offshore) ranged from 9.7 to 35.2 NTUs. Samples collected at TS 12 averaged 4.5 NTUs. These results indicate the vast range of water quality conditions occurring in the nearshore and offshore communities.

4.5.3 Nutrients

A wide variety of species common in these habitats range from and include plankton, filter feeders, invertebrates, sharks and the snapper-grouper reef fish complex. Fish and invertebrate species occur where physical and chemical characteristics (i.e., temperature, DO, salinity, clarity) suit their physiological requirements. Differences in the chemical and physical properties of the water affect the biological components of the water column - including larval transport and fish distribution.

The New River is subject to anthropogenic stressors including urban development, sedimentation, fertilizers, human and swine waste, and, as a result, has become eutrophic and occasionally hypoxic. The North Carolina Division of Environmental Management declared the New River as "nutrient sensitive waters" in 1988 to avoid permitting any new wastewater discharge points into the river system (Mallin *et al.*, 2005).

Significant N inputs in the form of ammonia [NH_4^+], nitrate [NO_3^-] and nitrite [NO_2^-], referred to as nitrogen loading (or anthropogenic input), can be attributed to sewage treatment plants, livestock waste and fossil fuels in some coastal areas (Howarth *et al*., 2000; 2002). In coastal rivers and oceans, non-point sources such as agricultural land practices (animal feeding operations, crop lands) or fossil fuel combustion are the primary contributor of nitrogen (Carpenter *et al*., 1998). In the northeastern United States, fossil fuel combustion is the leading cause of N input to coastal waters (Howarth *et al*., 2002). Nitrogen from the burning of fossil fuels is transported to the coast by deposition of airborne particulates over coastal waters (i.e., atmospheric deposition). However, Diaz (2001) identifies agriculture as the 'key generator of nitrogen' to coastal waters.

Carpenter *et al*. (1998, p. 5) indicate that phosphate (orthophosphate [PO_4]) loading from point sources provides the "highest input of P in many marine environments". Point-source runoff of P can include direct discharge from construction sites from exposed unconsolidated sediments. Carpenter *et al*., (1998) found a positive correlation between an increase in population density in watersheds with the input of P to the rivers and oceans. Sewage, in the form of both human and agricultural waste, is also a primary P contributor (Howarth *et al*., 2000; 2002).

4.6 AIR QUALITY

According to the EPA, air qualities at the closest monitoring stations (Wilmington and Jacksonville) have air quality indices well below the State and National Ambient Air Quality Standards (USEPA, 2001). Ambient air quality standards are based on six common pollutants: particulate matter less than 2.5 m (PM-2.5); particulate matter 2.5 to 10 m (PM-10); carbon monoxide (CO); ozone (O3); sulfur dioxide (SO2); nitrogen dioxide (NO2); and lead (Pb). The NCDENR, Division of Air Quality has jurisdiction over air quality in Onslow County; and, as of 2005, ambient air quality for the New River Inlet area was in compliance with the National Ambient Air Quality Standards (W. Cornelius, pers. comm.).

4.7 PUBLIC SAFETY

Public safety issues described below primarily refer to navigational practices in New River Inlet.

According to the North Carolina Wildlife Resources Commission, Division of Enforcement, 368,636 boats were registered in 2005, with 5,945 boats registered in Onslow County (NCWRC, 2005). In 2005, the U.S. Coast Guard ranked North Carolina as 10th nationally (tied with Illinois) in total number of boating fatalities. A total of 215 boating accidents were recorded by the NCWRC in 2005 (including personal watercraft), 14 of them fatal. Five of the 215 accidents that occurred in Onslow County, of which, zero were fatal. Of those accidents occurring in Onslow County, one occurred in the New River (NCWRC, 2005).

4.8 AESTHETIC RESOURCES

Topsail Island is a popular vacation spot that includes the Towns of Topsail Beach, Surf City and North Topsail Beach. New River Inlet is located at the northern end of Topsail Island, a 22-mi long barrier island with sandy beaches, maritime forests and estuarine habitats. Camp Lejeune Marine Corps Base is located on the northeast side of the Inlet. The 92-mi perimeter of Camp Lejeune includes 11 mi of Atlantic Ocean frontage, consisting of sandy beaches and a fragile barrier island system, separated from the mainland by salt marshes, small bays, and the Atlantic Intracoastal Waterway (USMC, 2006). Upland sites are characterized by highly productive pine and mixed pine/hardwood forests, while the bottomlands typically have wide flood plains with cypress and gum-swamps and headwaters composed of pocosins.

There is a natural aesthetic beauty to New River Inlet and the surrounding areas that provide uninterrupted natural vistas from salt marsh to barrier island ocean views. Overall, there are many photographic opportunities for scenic and wildlife pictures in and around New River Inlet.

4.9 RECREATIONAL RESOURCES

New River Inlet contains areas of maritime forest, shrub thickets, estuarine creeks, and salt marshes. Designated Significant Natural Heritage Areas in the vicinity of the Permit Area include the New River Inlet Outcrop.

The estuarine environment of the New River is a known nursery and safe haven for many game and recreational fish. Camp Lejeune Military base supports fish and wildlife resources for use by military and civilian personnel. Camp Lejeune has been listed as one of the top 10 military installations in the United States for deer hunting with over 1,000 deer taken annually. The Integrated Natural Resource Management Plan developed by Camp Lejeune assists in providing sound, scientific management of hunting and fishing programs exhibited by Camp Lejeune, which are necessary to maintain healthy populations of game species that meet recreational demand and minimize human and wildlife conflicts.

The following marinas were contacted by phone in August 2007 by CPE Staff to confirm hours of operation and proximity to the New River Inlet (NRI):

Paradise Landing - open; approximately a 15 minute boat ride to NRI and provides boat and personal watercraft rentals, and charter fishing.
Swan Point Marina – boat ramp is currently out of commission but marina is still in operation; approximately 5 minute boat ride to NRI.
New River Marina – open; approximately a 5 minute boat ride to NRI.
Sea Haven Marina –open.
Old Ferry Marina –open.
High-rise Bridge Boat Ramp – located on Shrimp Lady Lane, NTB 28460. This boat ramp provides access to the intracoastal waterway.
Soundside Park Boat Ramp – located at Surf City swing bridge.

The beaches of Topsail Island also provide a variety of excellent scenic and recreational opportunities for the public. Popular activities include, but are not limited to, surfing, fishing, swimming, walking, shell hunting, sunbathing, bird watching, kayaking and boating. Seaview Pier provides local fishing just south of the New River Inlet. Fishing activities also occur along the North Topsail Beach side of the inlet where public access is available. River Road provides automobile access for scenic driving along the inlet and parking is available on overwash features. Scenic vistas of the ocean are many; however, erosion of the beach has contributed to significant losses of dry beach areas, limiting many beach activities to occur during low tide periods.

4.10 NAVIGATION

New River Inlet serves as the access point for several recreational and fishing vessels year round. During the year, especially during peak tourist season, the Inlet can experience intense recreation navigation usage. Federally authorized and maintained channels in the vicinity of New River Inlet include: the Atlantic Intracoastal Waterway which has an authorized depth of 12 ft below MLW and a bottom width of 90 ft; a navigation channel 90 ft wide with an authorized depth of 10 ft below MLW from the AIWW through New River to the City of Jacksonville; and a 6-ft deep by 90-ft wide channel through the Inlet's ebb tide delta to the AIWW via Cedar Bush Cut.

Both commercial vessels (45 to 50 ft in length) and recreational boats (16 to 35 ft in length) utilize the Inlet, as well as military vessels traveling to and from Camp Lejeune Marine Corps Base. New River Inlet is not limited to seasonal usage, since it is used for a variety of navigational uses throughout the year.

4.11 HISTORIC PROPERTIES AND CULTURAL RESOURCES

4.11.1 Offshore Borrow Area Cultural Resources

The final offshore borrow area acreage is 482 acres. Of this acreage 149 acres were previously surveyed during the USACE archaeological remote sensing survey of Surf City and North Topsail Beach offshore borrow areas (MATER, 2005). In 2007, another survey was conducted by CPE who subcontracted Tidewater Atlantic Research, Inc., of Washington, North Carolina (See Appendix E – Cultural Resource Investigations: TAR, 2007). This survey included a systematic magnetometer and side-scan sonar survey of the offshore borrow area not previously surveyed for submerged cultural resources. The survey was designed to 1) locate and identify submerged cultural resources in the study area, 2) generate sufficient data to make an initial assessment of each target's significance, and 3) provide opportunities for avoidance measures. The results of this survey determined that no submerged cultural resources were identified in this location. The investigations carried out by TAR (2007) and MATER (2005) provided coverage of the entire North Topsail Beach Borrow Area. The portion of the proposed offshore Borrow Area previously surveyed and cleared by MATER (2005) for the USACE was found to have no anomalies. As no evidence of submerged cultural resources were identified by either survey, no additional investigation is recommended in conjunction with the proposed project. Analysis of the TAR survey data (TAR, 2007) and review of the 2005 MATER report confirms that no submerged cultural resources will be impacted by excavation of the proposed borrow area (Appendix E).

4.11.2 New River Inlet Channel Cultural Resources

A separate systematic proton precession magnetometer and sidescan sonar survey of a preliminary proposed ocean bar channel alignment location was also conducted by TAR (2005). The survey was conducted in October and November of 2004, which revealed a total of 111 magnetic and/or acoustic anomalies. Of those, 29 were identified as having a moderate or high potential association with shipwreck material and/or other submerged cultural resources. In addition, 14 of the 29 anomalies were comprised of four discrete clusters, which may be associated with previously documented wrecks or cultural material observed along the west bank of New River. Due to the findings of this report, the proposed channel design was shifted to the southwest to avoid the above mentioned potential cultural resources. Refer to Appendix E - Cultural Resource Investigations.

A cultural resource survey was conducted of the final proposed ocean bar channel at New River Inlet in October and November of 2007 (See Appendix E – Cultural Resource Investigations: TAR, 2008). Based on the results of both the 2005 and 2008 New River Inlet remote-sensing investigations, no National Register of Historical Places (NRHP) eligible submerged cultural resources will be impacted by dredging associated with the realignment of the ocean bar channel at New River Inlet. No additional investigation of the project area was recommended in conjunction with the proposed project (See Appendix E – Cultural Resource Investigations: TAR, 2005 and 2008).

4.12 SOCIO-ECONOMIC

Topsail Island is comprised of three Towns: North Topsail Beach, Surf City, and Topsail Beach. North Topsail Beach is the second largest of the three and has experienced slow growth since 2000. The Town had a population of 855 in 2005, up only 1.4% from 2000. Topsail Beach is the smallest Town on the island, with a population of 535 in 2005, although the growth rate from 2000 is larger than that for North Topsail Beach (13.6%). Surf City is the largest Town on the island, with a population of 1,619 in 2005, up 16.2% from 2000 (North Carolina State Demographics, 2006).

Although the island is a popular vacation spot, North Topsail Beach itself only supports three restaurants. As a result, visitors and residents travel to Sneads Ferry to the north or Surf City to the south for shopping and additional dining. North Topsail Beach does support many oceanfront condos and vacation rentals. Surfing, waterskiing, jet skiing, and wind surfing are a few of the recreational activities available to visitors of North Topsail Beach. However, in many places, high erosion rates can limit beach use to low tide events.

Based on the 2006 property reappraisal, the tax base for North Topsail Beach totals $1.49 billion. Approximately $0.79 billion of the total tax base is oceanfront property. The property tax rate for Onslow County was $0.67 per $100 valuation in 2005; while the 2005 tax rate for the Town of North Topsail Beach was $0.45 per $100 valuation. Note that both the County and Town tax rates will be adjusted based on the 2006 reappraisal. Refer to Appendix B - Engineering Report for a detailed economic assessment of North Topsail Beach.

4.13 LAND USE

The Coastal Area Management Act (CAMA) requires Counties, Cities and Towns within the 20 coastal counties to periodically prepare Land Use Plans to protect and manage the health of the coastal environment and economy. The North Carolina Division of Coastal Management requires that these counties keep the Land Use plans up to date. CAMA Areas of Environmental Concern are classified as conservation and include all areas within the Permit Areas. Land use community decisions are based on the seasonal or peak population months. Land use plans developed by Onslow County are intended to be an integral and sensible part of North Carolina environmental law.

The Onslow County Joint Land Use Study was updated in February 2003, and, according to the Town's Planning Board, the State has adopted new guidelines for Land Use Planning which will result in a more comprehensive plan for the Town. North Topsail Beach has recently received $35,000 in grant funding for the update process, which will take over two years to complete.

4.14 HYDRODYNAMICS

4.14.1 Tides and Tidal Flow

The mean tide range in the Atlantic Ocean in the vicinity of New River Inlet is 4.3 ft. The primary tidal datum is the North American Vertical Datum of 1988 (NAVD). The relationship between NAVD and other tidal datum are as follows:

Mean Higher High Water …… +1.74 ft NAVD
Mean High Water (MHW)…… +1.40 ft NAVD
NAVD '88 ……+0.00 ft NAVD
Mean Tide Level (MTL)……..-0.70 ft NAVD
NGVD '29…… -0.95 ft NAVD
Mean Low Water (MLW)……-2.81 ft NAVD
Mean Lower Low Water (MLLW)…… -2.96 ft NAVD

The tidal prism of New River Inlet, i.e., the total volume of water flowing through the Inlet during an ebbing tide or flooding tide, was determined based on flow simulations using the Advance Circulation Model for Shelves, Coasts, and

Estuaries (ADCIRC). Based on these flow measurements, the existing entrance ebb tidal prism was 784,000,000 cu ft while the existing entrance flood tidal prism was 598,000,000 cu ft.

O'Brien (1969) discovered a strong relationship between the cross-sectional area of an Inlet (measured at mean sea level) and its spring tidal prism. This relationship comes about as a result of the natural balancing of tidal flow forces that tend to scour the Inlet and littoral transport that deposits sediment in the Inlet. Jarrett (1976) developed refinements in the functional relationship between an Inlet's cross-sectional area and its tidal prism by considering inlets on the Atlantic, Gulf, and West Coast of the U.S. as well as whether the Inlets were stabilized with one jetty, two jetties, or not stabilized by structures (refer to Appendix B - Engineering Report). For inlets on the Atlantic Coast of the U.S., this relationship is given by:

$A = 5.37 \times 10^{-6} \ P^{1.07}$ (Jarrett, 1976)
Where: A = Minimum cross-sectional area in square ft
P = Spring tidal prism in cubic ft

The minimum cross-sectional area of New River Inlet obtained from the October 2001 survey by CSE was 13,600 sq ft. The cross-sectional area predicted by the above equation for the average tidal prism of New River Inlet (i.e., the average of the flood and ebb tidal prisms) is 14,700 sq ft. The agreement between the measured and predicted inlet cross-sectional areas is rather good considering inlets are known to undergo short-term fluctuations in their cross-sectional area on the order of ±10% (due to high sediment loads during storms or as a result of changing lunar or meteorological tide conditions). The agreement between the measured and predicted minimum cross-sectional area indicates that New River Inlet maintains a balance between the hydraulic forces tending to keep it open (tidal flow) and sedimentary forces (littoral transport) that would tend to close it. The hydrodynamics of New River Inlet were evaluated using the Advanced Three-Dimensional Circulation Model for Shelves, Coasts, and Estuaries (ADCIRC). The model was constructed from a detailed hydrographic and topographic survey of the Inlet by CPE in July 2003 with supplemental soundings from the Corps of Engineers and National Ocean Service navigation charts. The model was calibrated and verified with water levels obtained from NOAA and measured during the 2003 hydrographic survey. Details of the numerical model investigation are provided in Appendix B -Engineering Report.

4.14.2 Waves

Wave information for the New River Inlet area was obtained from the Wave Information Study (WIS) conducted by the U.S. Army Corps of Engineers - Engineering Research and Development Center, Coastal Hydraulics Laboratory located in Vicksburg, Mississippi. The WIS wave information is based on a 20-

year hindcast (1976 to 1995 inclusive) of wave conditions based on synoptic wind patterns over the entire Atlantic Ocean basin and includes the effects of hurricanes and other tropical storms. The wave information is provided in three-hour increments for the entire 20-year period. The WIS station used is designated as AU2044 and is located directly offshore of New River Inlet in a water depth of 72 ft (Appendix B-Engineering Report). The general alignment of the shoreline in the vicinity of New River Inlet is North 60 degrees East; therefore, waves propagating from the north-northeast clockwise around to the west-southwest are moving onshore. Based on the percent of wave energy moving in the onshore direction, 63.8% of the wave energy would tend to move sediment in a southwesterly direction and 36.2% of the wave energy would move sediment in a northeasterly direction.

4.14.3 Littoral Transport

The wave information provided for WIS Station AU2044 was used to compute the average longshore sediment transport potential in the vicinity of New River Inlet and along the ocean shoreline of North Topsail Beach for each year between 1976 and 1995. Details of the sediment transport estimates, including average monthly sediment transport rates, are provided in Appendix B – Engineering Report.

The computation of potential sediment transport rates using wave hindcast information reported in Appendix B followed the methodology outlined in the U.S. Army Corps of Engineers Coastal Engineering Manual, EM 1110-2-1100 (Part III) 30 Apr 02, Chapter 2, Longshore Sediment Transport. The wave information reported for the WIS Hindcast Station is transformed from the water depth at the wave information site (72 feet in this case) to shallow water using Snell's Law and conservation of wave energy flux. Snell's Law is given as:

$$\frac{\sin \alpha_b}{C_b} = \frac{\sin \alpha_1}{C_1}$$

Where: α_1 = Wave angle relative to the shoreline in the water depth at the WIS hindcast station
α_2 = Wave angle relative to the shoreline near the point of breaking
C_1 = Wave Celerity in the water depth at the WIS hindcast station
C_2 = Wave Celerity near the point of breaking = $(gd_b)^{1/2}$
d_b = Water depth at point of breaking

Using the breaker angle determined from the application of Snell's Law, the potential longshore sediment transport associated with each wave condition is computed by the following equation:

$$Q = 7500(.00996)\rho g^2 T(H_{s1})^2 (\sin \alpha_2) (\cos \alpha_1) (3 \text{ hrs./t})$$

Where: Q = Potential longshore sediment transport rate (cy/yr)
ρ = mass density of seawater (1.99 slugs/ft^3)
g = acceleration due to gravity (32.2 ft/sec^2)
T = wave period in seconds for the 3-hr hindcast
H_{s1}= Significant wave height for the 3-hr hindcast
α_1 = angle between wave crest and shoreline in at the WIS station
α_2 = angel between wave crest and shoreline near the break point
t = number of hours in a year

4.15 INFRASTRUCTURE

World War II had a tremendous impact on the migration of immigrants to the United States in the mid to late 1900's. North Carolina began to notice the effects of this migration as evidenced by the steady increase in infrastructure and development in the 1970's (Carteret County, 1999). This increase in population and development was most noticeable along the North Carolina coastline. Recently, the population for Onslow County has increased from 150,355 in 2000 to 152,440 in 2005 (USCB, 2006).

Military facilities such as the U.S. Marine Corps Air Station base at Cherry Point in Havelock, U.S. Marine Camp Lejeune base at Jacksonville and port at Morehead City, and U.S. Air Force Base Seymour Johnson in Goldsboro, have all contributed significantly to population increases along the North Carolina coastline. Camp Lejeune is situated closest to and, as such may have the most impact on the population of Topsail Island and North Topsail Beach.

Over the past 25 years, the recreational and retirement centers have shifted the permanent population and economic structure along coastal communities in North Carolina. The high seasonal population has changed the economic structure of these communities to a service and retail oriented industry. However, infrastructure in North Topsail Beach is still limited as the Town remains primarily a low-density residential area with little development.

4.16 URBAN QUALITY

The location of the Permit Area assessment is within an inlet and beach environment and therefore does not involve urban quality issues.

4.17 SOLID WASTE

The Solid Waste Management Act of 1989 regulates the safe disposal and management of solid wastes; more specifically the reduction of wastes in North Carolina. A Solid Waste Management Plan was adopted in 1991 and updated in 2003. There are currently 39 operating lined Municipal Solid Waste Landfills (MSWLF) in the State of North Carolina. However, the challenge continues for

the State as the volume of material needing to be disposed of increases, while the amount of available landfill space decreases (NCDWM, 2006).

Multiple MSWLFs exist in Onslow County. The nearest operating facilities to North Topsail Beach include Camp Lejeune Municipal Solid Waste Landfill and Onslow County Landfill.

4.18 DRINKING WATER

Similar to other rural areas, the primary public water supply source for Onslow County is fed by a groundwater source (USEPA, 2002). The groundwater source (Castle-Hayne Aquifer) of the coastal plain region of North Carolina is available in the pore spaces of both consolidated and unconsolidated stratified materials such as clay, sand, gravel and shell. These aquifers are considered to be high yielding for the municipalities utilizing them (GWPC, 2003).

The watershed system, called the New River Watershed (USGS Cataloging Unit 03030001), supplies groundwater to the surrounding cities, towns, and islands around New River Inlet, including North Topsail Beach.

4.19 ECONOMICS

An economic assessment of the proposed shoreline protection project is described in detail in Appendix B – Engineering Report.

4.20 NON-RELEVANT RESOURCE ISSUES

The following section describes resources that are considered to be insignificant due to the scope of the project alternatives.

4.20.1 Hazardous, Toxic and Radioactive Waste

No chemical analysis of the sediments within the proposed channel has been performed to date. It is unlikely that the project area sediments have accumulated hazardous, toxic, or radioactive substances regulated by CERCLA or RCRA. There are currently no hazardous, toxic, or radioactive waste producers adjacent to or known discharges of contaminants to Onslow Bay (CSE, 2001).

There were no bulk storages of hazardous materials, no toxic waste dump sites, and no disposal of toxic wastes found in Onslow County based on a Camp Lejeune Environmental Assessment (EA) (USMC, 2002). A source of hazardous materials may be Camp Lejeune Marine Base. In North Carolina, there are concerns with contaminants at military bases. Some military-related contaminants of concern include VOCs, PCBs, PAHs, heavy metals, pesticides,

and solvents. In 1989, the NOAA Coastal Resource Coordination Program conducted a coastal hazardous material site review for Camp Lejeune which was contaminated with pesticides and PCBs (NOAA Office of Response and Restoration, 2003). Camp Lejeune also routinely conducts Shore Fire Control Party Training. This entails firing onto the camp in a practice attack. During the attacks, there is repetitive artillery fire. According to the Environmental Assessment (July, 2002), 99% of rounds fall within the Naval Gunfire Impact Area and the potential for rounds to fall short is less than 0.01%.

Direct concerns with contaminants in New River Inlet can come from local businesses. There are no large industries in the area, but small business, such as paint shops can put contaminants directly into the estuarine waters.

4.20.2 Noise

Since North Topsail Beach is primarily a residential area, ambient levels of noise in the area are relatively low. However, noise from Camp Lejeune Military Base includes military aircraft, submersible soundings, and exploding devices, each of which contributes to air, land and sea noise disturbances.

4.20.3 Energy Requirements and Energy Conservation

Energy requirements for this type of project assessment would be confined to fuel for operating machinery, labor transportation, and other construction type equipment.

The energy conservation potential associated with the assessed project activity includes the reuse of sand for beach nourishment and the relocation of existing structures.

No other energy requirements or conservation measures have been identified.

5.0 ENVIRONMENTAL CONSEQUENCES

This section involves both a qualitative and quantitative comparative assessment of the alternatives, as discussed in Section 3.0, and their potential effect on known resources. The following section includes the anticipated changes to the existing environment including direct, indirect, and cumulative effects within the Permit Area (see Section 4.1 for Permit Area description). A summary of the impacts and changes expected to result from the implementation of each alternative is presented at the end of this section (Table 21).

As discussed in Section 1, the Town of North Topsail Beach is seeking Federal and State permits to allow implementation of a non-Federal shoreline and inlet management project that would preserve the Town's tax base, protect its infrastructure, and maintain its tourist oriented economy (see Section 1.6 for details). The goals, needs and objectives of the North Topsail Beach Shoreline Protection Project are summarized as follows:

- Long-term stabilization of the oceanfront shoreline located immediately south of New River Inlet;
- Provide short-term protection to the 31 imminently threatened residential structures over the next zero to five years;
- Provide long-term protection to Town infrastructure and approximately 1,200 homes;
- Reduce or mitigate for historic shoreline erosion along 11.1 miles of oceanfront shoreline of North Topsail Beach;
- Improve recreational opportunities along the Town's oceanfront shoreline;
- Acquire beach compatible material for shore protection project;
- Maintain the Town's tax base by protecting existing development and infrastructure on the oceanfront shoreline of North Topsail Beach; and
- Balance the needs of the human environment by minimizing and avoiding negative effects to natural resources.

Table 21, shown below, provides a summary of the impacts expected to result from the implementation of each alternative. Physical direct (1 to 2 years), indirect (5 to 10 years) and cumulative (more than 30 years) effects of alternatives on habitats were calculated as acreage amounts and are based on the following: